

**State of Washington resource agencies
Department of Fish and Wildlife
Department of Ecology**

INTRODUCTION

The Washington Department of Ecology (WDOE) is charged both with administering state water rights laws and the federal Clean Water Act. Chapters 90.54 and 90.22 RCW require Ecology to maintain instream flows sufficient to protect and preserve fish and wildlife habitat, scenic and aesthetic values, navigation and other environmental values. Water right permits will be conditioned with instream flow requirements to protect these values.

For projects requiring a federal license or permit involving a discharge into navigable waters, a section 401 Water Quality Certification will be required. Ecology is required to condition certifications to ensure compliance with state water quality standards and to prevent the degradation of existing uses such as fish and wildlife habitat, recreation and aesthetics.

The Washington Department of Fish and Wildlife (WDFW) recommends instream flows to be conditions of water rights or Clean Water Act Section 401 certification (issued by WDOE) and hydroelectric power project licenses or exemptions (issued by the Federal Energy Regulatory Commission - FERC). When a major water project is planned, WDFW and WDOE request that the project proponent conduct an instream flow study in consultation with the agencies to provide adequate information on which to base an instream flow recommendation or requirement. WDFW defines a major water project is a project that (a) diverts at least 1.0 cubic feet per second (cfs), and (b) changes flow by at least 10% of the monthly 90% exceedence flow at any point along the stream channel.

The purposes of WDFW's instream flow recommendation are: (1) to avoid reduction of habitat for fish and wildlife; (2) to ensure fish passage upstream and downstream; and (3) to maintain macrohabitat features of the stream channel.

To address fish habitat, WDFW and WDOE request use of an instream flow method which estimates the amount of habitat available at different flows which might occur with and without the proposed project. In most cases, this request is met by using the Physical Habitat Simulation (PHABSIM), part of the Instream Flow Incremental Methodology (IFIM), following quality control and model limitations consistent with the Instream Flow Study Guidelines.

A consultation documentation form is provided on the following page. Consultation with appropriate WDFW and WDOE personnel and adherence to the attached IFIM study guidelines during all phases of the instream study is crucial to completion of the study. We request documentation of each step of consultation by signature of a WDFW Habitat Management Program employee on the form on the following page. Primary contacts should be:

- Hal Beecher, WDFW Instream Flow Biologist, Olympia, 360-902-2421
- Brad Caldwell, WDOE Water Resources Program, Olympia, 360-407-6639
- Jeff Marti, WDOE Water Resources Program, Olympia, 360-407-6636

PROJECT: _____
STREAM: _____
FERC#: _____

DOCUMENTATION OF CONSULTATION WITH WDFW ON INSTREAM FLOW STUDIES - ALL BLANKS
MUST BE SIGNED BY WDFW PERSONNEL FOR COMPLETION OF CONSULTATION

SCOPING

Study site(s) approved _____ date __/__/__
Transects approved _____ date __/__/__
Target measurement flows approved _____ date __/__/__

HYDRAULIC MODEL

Measured flows approved _____ date __/__/__
Hydraulic model approved for the following ranges:
_____ date __/__/__

HABITAT PREFERENCE CURVES

Preference curve study design approved (including species, lifestages) _____ date __/__/__
Preference curve study completed _____ date __/__/__
Preference curves approved (copy to be attached) _____ date __/__/__

INSTREAM FLOWS - LIST BY TIME PERIOD:

MONTH/DATE to MONTH/DATE MINIMUM FLOW (cfs)

_____/____/____ to _____/____/____ _____
_____/____/____ to _____/____/____ _____

FLUSHING FLOW REQUIREMENT - >48 HRS/3 YRS _____ cfs

Approved by Department of Fish and Wildlife

_____ date __/__/__
Instream Flow Biologist

_____ date __/__/__
Regional Habitat Biologist

Evaluating Instream Flows For Fish

When an existing or proposed project affects flow in a river or stream (i.e., hydropower, irrigation, or municipal/industrial diversions), the Washington state resource agencies, including the Washington Department of Ecology (WDOE) and Washington Department of Fish and Wildlife (WDFW), often request studies to evaluate the impacts of altered flow on instream resources, including fish habitat and production, for the purpose of making decisions or recommendations on water use. Instream flow study guidelines are for fish impacts.

Altered stream flows have two types of impacts that affect fish: (1) flow alteration and (2) flow fluctuations. Flow alterations are defined as changes over substantial periods of time (i.e., weeks or longer). Flow alterations change the amount and type of instream habitat and, in turn, change fish production and fish species composition. Direct measurement of this impact in terms of lost fish production is difficult. However, a widely used method called the Instream Flow Incremental Methodology (IFIM) (Bovee 1982, Milhous, et al. 1984) is useful for determining the flows needed to maintain the fish production potential of a stream or river.

IFIM uses several computer models to determine how habitat indexes change with changes in flow. The habitat indexes (Weighted Usable Area or WUA) at each flow correspond to biological requirements of the species and life history stage of fish of interest. Results of an IFIM study are projections of WUA for each sensitive species/life history stage over a broad range of flows. From this information, the resource agencies recommend a flow requirement (usually a minimum flow requirement) needed to maintain the fish production potential of the stream.

A word of caution. IFIM is not a fixed linear sequence of procedures, but involves a number of important subjective decisions (e.g., transect selection, selection of specific computer models and parameters, weighting schemes). Selection of ramping transects (see below) is also subjective. For this reason, the Washington state resource agencies require ongoing consultation during a study, including several meetings and field trips. Studies performed without adequate consultation may be partially or completely rejected, resulting in significant delays in project development.

Other Instream Flow Values

An IFIM study produces information on the relationship of flow and fish habitat. The quantity and timing of instream flow also affects recreation (boating, fishing, swimming, wading, etc.), aesthetics, water quality, channel maintenance, riparian vegetation and other environmental values. Thus, a project proponent should be prepared to perform other studies as necessary, including monitoring, to determine flow requirements for other values.

In addition, flows deemed suitable for fish habitat may differ from those deemed necessary for another instream value. In some cases, they may be in direct conflict. An interdisciplinary approach to search for ways to reconcile and accommodate different resource needs is recommended (see Jackson et al. 1989).

Ramping Rates and Ramping Rate Studies

Interim ramping rates will be established according to Hunter (1992):

Season	Daylight Rates*	Night Rates
February 16 to June 15 (salmon fry)	No Ramping	2 inches/hour
June 16 to October 31 (steelhead and trout fry)	1 inch/hour	1 inch/hour
November 1 to February 15	2 inches/hour	2 inches/hour
	*Daylight is defined as one hour before sunrise to one hour after sunset	

The rate of change of streamflow when diversion is started, stopped, or changed is referred to as the ramping rate. Ramping rate is a concern for fish protection because rapid decrease in flow can strand fish on gravel bars, as well as dewatering fish eggs. Drops in flow, even as little as 1 inch of water surface elevation per hour, can impact fish populations. Other effects, including depletion of aquatic invertebrates on which fish feed, and behavioral responses to changes in flow, may also reduce fish production but are not as well understood.

The impacts of flow fluctuation are mitigated by specifying a rate of flow reduction, the ramping rate, and specifying times during the day and year at which ramping can occur. For most projects, a standard interim ramping rate and ramping schedule are provided early in consultation by the agencies. Studies and agency consultation will assist in identifying ramping transects and critical flows. Ramping transects are evaluated to determine the maximum rate of flow change to meet interim ramping rates, so that engineers have specific design criteria to work with. The type of data needed is similar to that collected for part of the IFIM study, and it may be convenient to collect these data concurrently. IFIM is inappropriate for assessing effects of flow fluctuations because it measures habitat rather than mortality.

PURPOSE OF INSTREAM FLOW STUDY

The instream flow study should produce information on the relationship between flow and fish habitat. This is not the only information that will be considered; it will be used as one of several pieces of information necessary for state natural resource agencies to make recommendations and decisions. Factors to be considered in agency flow recommendations might include (1) fish access to tributaries at proposed flows, (2) other fish passage considerations, (3) proximity of suitable hydraulic conditions to cover for fish, (4) "ground-truthing" and professional judgement of proposed flows indicated as suitable by models, and (5) results of monitoring.

KEY ELEMENTS OF INSTREAM FLOW STUDY

Consultation with the appropriate state agency personnel and personnel of other resource management agencies (including U.S. Fish and Wildlife Service, National Marine Fisheries Service) and Indian tribes is the responsibility of the project proponent at all stages of the study. Stages of the study include:

- (1) planning or scoping - develop study plan & obtain signed approval from all parties;
- (2) fish habitat preference curve verification based on study plan pre-approved by agencies;
- (3) field data collection;
- (4) hydraulic model calibration;
- (5) habitat model runs;
- (6) interpretation of habitat models and development of proposed instream flow recommendations, including field review and finalization of proposed instream flow recommendations;
- (7) monitoring of impacts of project with instream flows in place.

Each stage will be discussed below with indications of agency preferences for techniques, programs, and emphasis.

PLANNING

Early in the planning phase, when the project is still flexible, the project proponent should schedule a meeting when representatives of all agencies and tribes can attend. At least 2 weeks notice is usually necessary. The purpose of the meeting is to discuss possible project designs and develop a study plan to assess the potential impacts of all different designs on instream resources.

In preparation for the meeting, the project proponent should conduct a thorough reconnaissance of the stream reach to be affected by the project. Reconnaissance should include stream reach downstream from project at least to next major confluence. Documentation of the reconnaissance that expedites agency review and planning includes:

- (1) map with contour intervals no greater than 20 feet;
- (2) graph of elevation plotted with distance along the stream;
- (3) low altitude photo mosaic (preferred) or video tape of entire reach (low flow in winter is best);

- (4) on-the-ground photos or video tape of all habitat types and potential barriers to fish migration (with reference object for scale in pictures of potential barriers);
- (5) list of fish species known or expected in stream reach;
- (6) available hydrological data such as 10%, 50%, and 90% exceedence discharges by month; and information on derivation of data.

The proponent should conduct an instream flow study using PHABSIM with the 3-flow IFG4 as the hydraulic model unless otherwise approved in advance by all agencies. In preparation for the planning meeting or a follow-up site visit, the proponent should select and mark tentative transects to represent all habitats in the affected reach, including ramping rate transects both in the bypass reach and downstream of the powerhouse. Someone with IFIM experience should select these tentative transects. A site visit under suitable viewing conditions allows agency representatives to view, modify as needed, and approve placement of transects.

The final product of the planning meeting is a study plan signed by all parties agreeing to the plan. It should be as specific as possible. It should ensure that all parties understand what is expected from the study. It should ensure the project proponent that the study is not open-ended, thus allowing scheduling and budgeting of the study. It should be amendable only by unanimous agreement of all parties. The following elements should appear in the study plan:

- (1) hydraulic model(s) to be used;
- (2) range of flows to be addressed and target calibration flows;
- (3) hydrographs to be used in analysis;
- (4) locations of transects and study sites with maps and photos or videos as documentation;
- (5) habitat preference curve verification study plan (see below);
- (6) habitat models to be used (HABTAT, HABTAV, HABTAE, feeding stations, plunge pool);
- (7) fish passage flow determination procedure and criteria;
- (8) channel macrohabitat maintenance flow determination procedure;
- (9) any limiting factor analysis or time series analysis;
- (10) ramping rate study plan and sites.

FISH HABITAT PREFERENCE CURVE VERIFICATION

An instream flow study is incomplete if the project proponent has not made a reasonable effort to determine fish habitat preference at the study site or an approved substitute site. The study outlined here is a reasonable effort. If, after making a reasonable effort, the project proponent has not compiled enough data to verify or modify agencies' fallback or generalized habitat preference curves, then fallback curves may be used (see below and Appendix for discussion of fallback preference curves). Agencies will not modify fallback curves unless data collected at the site using a study plan pre-approved by the agencies. Preference curve verification may be aimed at selected species and life stages if those species and life stages will be given more weight in the development of an agency instream flow recommendation.

The preference curve verification study consists of three parts:

- (1) determine proportional habitat availability;
- (2) determine fish habitat utilization; and
- (3) analysis of fish preference or relative density by determining ratios of habitat utilization to habitat availability.

Useful references for habitat preference curve verification are Orth, Jones, and Maughan (1981), Bovee (1986, Instream Flow Information Paper No. 21), Slauson (1988), and Beecher, Johnson, and Carleton (1993).

Determining habitat availability. In PHABSIM the habitat dimensions of interest are depth, velocity, substrate, and cover. The simplest ways to determine the frequency of different ranges of habitat dimensions are either to map their distributions or to generate a table of their frequencies from PHABSIM based on an hydraulic model for the flow occurring during field measurements of habitat utilization. In either case, the field measurements of these dimensions should follow the procedures used for (and may coincide with) one of the IFG4 calibration flow measurements, as described by Bovee (1982, Instream Flow Information Paper No. 12) and Bovee and Milhous

(1978, Instream Flow Information Paper No. 5). This will require measurements of depth and velocities along transects placed to represent the full array of habitat types occurring in the study reach.

The frequency of a depth (or velocity or cover or substrate) range will be weighted by the weighting factor(s) for the transect(s) in which it is measured or simulated. If the preference curve verification study reach is smaller than the IFIM study reach which the transects were selected to represent, then different weighting factors may be required for determining habitat availability than are used for the IFIM study.

Determining fish habitat utilization. Fish habitat utilization measurements should not be made during nor immediately after habitat availability measurements. This will minimize disturbance of fish.

Fish observations should be conducted by one or more divers swimming slowly and cautiously upstream. Divers should avoid disturbing fish. If more than one diver is participating, divers should coordinate positions to avoid disturbing fish or double-counting them. Before recording depth, velocity, substrate, and cover where a fish is observed, the diver should determine that the fish is not disturbed. The observation is a good one if fish behavior includes (a) feeding, (b) territorial defense, or (c) returning to the observation point after measurement. (The diver may determine that an observation is a good one even if these behaviors are not observed.) Divers may either measure depths, etc. as they encounter fish, or they may mark fish positions with weighted flags and return to measure when all fish in the study site have been marked.

Analysis of fish habitat preference. The first stage in data analysis is to determine the final ranges (or bin size, Slauson, 1988) of each habitat dimension to be used. In many studies, small sample size of fish observations will limit how narrow those ranges will be.

Begin by using uniform initial ranges that are a reasonable size for the measurement equipment precision (e.g., 0.1 ft ranges for depth measurement with English unit wading rods). For each initial range, tabulate the proportion of preference curve verification study area that falls within that range. For example, we might find the following distribution of area in X Creek, listed with observed number of fish (O) in each range:

0.00-0.09 ft	1.3%	O= 0
0.10-0.19 ft	1.4%	O= 0
0.20-0.29 ft	4.3%	O= 0
0.30-0.39 ft	4.8%	O= 0
0.40-0.49 ft	5.1%	O= 0
0.50-0.59 ft	7.8%	O= 1
0.60-0.69 ft	9.7%	O= 3
0.70-0.79 ft	14.7%	O=23
0.80-0.89 ft	18.2%	O=26
0.90-0.99 ft	15.0%	O=21
1.00-1.09 ft	11.5%	O= 7
1.10-1.19 ft	4.6%	O= 3
> 1.19 ft	1.6%	O= 3.

If the diver had measured depth at 87 fish positions (N=87), the null hypothesis would be that fish were distributed independently of depth and should therefore be distributed at depths proportionally to the frequency with which those depths occur. The null expectation (E) of the number of fish in each depth range would be the product of N and the percent of total area in that depth range (D): $E=ND$. Depth ranges and corresponding values of E for X Creek are:

0.00-0.09 ft	E= 1.13
0.10-0.19 ft	E= 1.22
0.20-0.29 ft	E= 3.74
0.30-0.39 ft	E= 4.18

0.40-0.49 ft E= 4.44
 0.50-0.59 ft E= 6.79
 0.60-0.69 ft E= 8.44
 0.70-0.79 ft E=12.79
 0.80-0.89 ft E=15.83
 0.90-0.99 ft E=13.05
 1.00-1.09 ft E=10.01
 1.10-1.19 ft E= 4.00
 > 1.19 ft E= 1.39.

Ranges will be combined using the criterion that E should be at least 5 in most if not all ranges (a standard derived from chi-square tests, which may be used in preference curve development). Combining ranges yields the following:

0.00-0.29 ft E= 6.1
 0.30-0.49 ft E= 8.6
 0.50-0.59 ft E= 6.8
 0.60-0.69 ft E= 8.4
 0.70-0.79 ft E=12.8
 0.80-0.89 ft E=15.8
 0.90-0.99 ft E=13.0
 1.00-1.09 ft E=10.0
 > 1.09 ft E= 5.4.

The ratio O/E is calculated, then normalized (see Bovee, 1986) to create the preference factor so that the maximum value of P is 1.00:

0.00-0.29 ft O/E= 0.00 P=0.00
 0.30-0.49 ft O/E= 0.00 P=0.00
 0.50-0.59 ft O/E= 0.15 P=0.08
 0.60-0.69 ft O/E= 0.36 P=0.20
 0.70-0.79 ft O/E= 1.80 P=1.00
 0.80-0.89 ft O/E= 1.64 P=0.91
 0.90-0.99 ft O/E= 1.61 P=0.89
 1.00-1.09 ft O/E= 0.70 P=0.39
 > 1.09 ft O/E= 1.11 P=0.62.

These values of P could then be compared to agency fallback values and a mutually acceptable preference curve could be adopted for the X Creek IFIM study.

Fallback preference curves, including those for plunge pools, are listed in the Appendix or are available from the agencies.

Life-stage timing. Timing of spawning and emergence are often important determinants of what flows are required at different times. Temperature can be a critical factor in life-stage timing. Consequently, temperature should be monitored in affected reaches throughout the year. Surveys to determine timing of fry emergence should bracket the times when emergence is expected.

HYDRAULIC MODEL CALIBRATION

The agencies' first choice of hydraulic models is IFG4 using 3 sets of velocity measurements to establish regressions of velocity with flow. Agencies expect to review an hydraulic model based on measured data (unmodified input). We will consider additional models with minor modifications to the input on a case by case basis. If modifications improve extrapolation (i.e., more realistic velocities and better velocity adjustment factors at higher flows) without deterioration of interpolation, then modifications will be accepted.

The agencies request the following material for each hydraulic model calibration run (always include run with unmodified input):

- (1) field notes;
- (2) input file (bed elevations, water surface elevations, velocities, substrate/cover, and calibration discharges for IFG4; bed elevations, water surface elevations, roughness coefficients, substrate/cover, and calibration discharge for WSP or IFG2);
- (3) table for each transect of "calibration details" with simulated velocities paired with corresponding measured velocities for each calibration flow (thus, model needs to be run for calibration flow); or, if several "1-flow IFG4" models are being run, table of each velocity calibration flow measured velocities with predicted velocities (e.g., measured high flow velocities with extrapolated high flow velocities from medium flow and low flow models, and similar treatments of medium flow and low flow calibration measurements);
- (4) table of velocity adjustment factors (VAF) for each transect and each simulated flow over the proposed range of the model;
- (5) table of "computational details" for each simulated flow, including calibration flows;
- (6) list of options used in hydraulic model;
- (7) map of site showing placement of numbered transects in relation to pools, riffles, chutes, large boulders, large woody debris, and other channel features; and
- (8) table of stage differences between flows and between transects (for example:

	T1	diff	T2	diff	T3
400cfs:	91.20	0.10	91.30	0.15	91.45
diff	.10		.09		.10
200cfs	91.10	0.11	91.21	0.14	91.35
diff	.05		.07		.05
100cfs	91.05	0.09	91.14	0.16	91.30).

We recommend limiting extrapolation to flows at which all VAFs are between 0.80 and 1.20, and at which no simulated velocities exceed 10.00 feet per second. If it is necessary to model higher or lower flows, additional field work to allow calibration of an additional or extended model will be required.

Where possible, tie benchmarks together. We review stages of zero flow in different transects and expect them to make a normal upstream progression. If transects are modeled separately, this does not happen and our model review is prolonged.

Other hydraulic models can be considered as needed if conditions preclude a 3-flow IFG4, but these should only be used with prior approval of the agencies.

HABITAT MODEL

A major product of an instream flow study is a set of tables and graphs relating an index of habitat, such as weighted usable area (WUA), to flow. In PHABSIM, this is produced by HABTAT or similar program, with results being listed in TAPE 8. In the plunge pool analysis, which will be discussed below, an index comparable to WUA will be calculated manually.

Separate runs of HABTAT should be run for spawning and rearing or holding. Use cover for rearing and substrate for spawning in those cells where both are recorded.

In studies with multiple sites, the tables discussed above should be provided for each site individually and for all sites combined. The combined or composite tables should have results at each site weighted according to the area it represents.

The final report, in which these tables are presented, should also include:

- (1) the preference curves used with documentation of agency approval; and
- (2) a list of options used in HABTAT.

Plunge pool analysis. In some high-gradient, boulder- or bedrock-channel streams, the only fish habitat is in pools. This approach is based on the following assumptions about habitat quality in pools:

- (1) surface turbulence/bubble plume should cover about half the pool surface, and, as plume coverage increases beyond or decreases below half of pool area, habitat quality will decline rapidly;
- (2) pool area not covered by surface turbulence/bubble plume is valuable as habitat when depth equals or exceeds 0.5 foot or 10% pool width, whichever is greater, but any depth over 3.0 feet should be considered usable, subject to preference verification;
- (3) spawning habitat response to changes in flow in pools is best assessed by using standard IFIM transects with depth, velocity, and substrate measurements near tail of pool.

Pool habitat for juvenile and adult trout should be calculated as follows:

Habitat = area of calm, deep water X preference for ratio
of plume area to calm, deep area.

The field method for plunge pool analysis requires establishment of permanent transects and vertical depth measurement points ("verticals") along the transects. We recommend at least 3 transects. Record distances between transects. These transects should be visited at a number of different flows of interest. At each flow, depth should be measured at verticals up to 3.0 feet deep. Depths should be recorded with corresponding distances along transect. The person conducting the field work should identify the boundaries between plume and calm water and record the distances along each transect where they occur. If velocity is substantially greater than 1 foot per second, that point might be considered to be in the plume if the boundary is not otherwise obvious.

Photographs from the same high vantage point should be taken at each measurement. Colored flags at reference points along each transect will facilitate interpretation of photographs.

Feeding Station Analysis. Feeding station analysis uses hydraulic model results from PHABSIM to evaluate habitat for rearing territorial trout (Beecher 1987). It is an additional method for determining or confirming suitable instream flows. With this method, trout feeding stations are tallied as number of measurement points (cells) where depth is ≥ 0.5 foot, velocity < 1.0 ft/sec, and velocity in at least one of the adjacent cells ≥ 1.0 ft/sec and ≥ 0.5 ft/sec faster than in the cell of interest. Thus, a cell is considered a good feeding station if it is deep, slow, and adjacent to faster food-transporting current. Numbers of feeding stations are tallied at different flows.

INTERPRETATION OF HABITAT MODELS AND DEVELOPMENT OF INSTREAM FLOW RECOMMENDATIONS

The agencies will recommend instream flows which will not reduce habitat for the most flow-sensitive species and life stage. Flow recommendations based on model results (PHABSIM, plunge pool, and/or feeding station) are subject to field verification or "ground-truthing".

This approach has been oversimplified to "recommending the peak of the WUA vs. flow curve." However, our recommendations are tempered by our knowledge of hydrology of the site and effects of hydrology on fish (e.g., scouring of redds, incubation flows), agency management objectives and risk to species (e.g., greater emphasis on rainbow trout than on whitefish even though the more numerous whitefish typically occupy deeper, faster water), and on modeled responses of coexisting species to flow.

Time-series analysis. Project proponents may wish to do time-series analysis. The agencies neither request nor endorse the use of time-series. However, if requested to consider results of time-series analysis, agencies will accept such analyses only over the range of flows for which the hydraulic model is accepted by agencies. In addition, any time-series of alternative flow regimes must incorporate a temperature-based metabolism factor, the habitat-temperature index (HTI), into the analysis, as follows:

If two different flow regimes, A and B, lead to two different amounts of WUA, WUA(A) and WUA(B), at a given time, we can calculate a difference, $DWUA = WUA(A) - WUA(B)$. DWUA can be plotted against time and can be positive, negative, or zero. $HTI = 2^{*(T/10)*DWUA}$, where T is water temperature in degrees C at that season. HTI need not be used for spawning or incubation.

RAMPING RATE STUDIES

Information needed for ramping rate determination includes: (1) identification of critical sites, (2) determination of stage-discharge relationship at critical sites, (3) determination of travel time for a block of water traveling through a reach of interest, and (4) determination of attenuation of stage change over distance at different flows. Much of this information can be gathered conveniently concurrently with PHABSIM studies.

Critical sites are sites where juvenile fish are most likely to be stranded if stage is reduced rapidly. This can happen where the stream is wide and the cross section has a relatively flat slope, typically at a gravel bar or sand bar.

The applicant should identify potential critical sites both within the bypass reach and downstream from the powerhouse site. Following tentative critical site selection, agency personnel should be shown sites so that they can make a final decision on sites and transects.

The applicant should conduct a series of stage-discharge measurements at each critical site transect. A detailed cross-sectional profile should be determined by surveying elevations along each critical site transect. Stage-discharge measurements should identify critical flows, such as flows that coincide with inflection points on the cross-sectional profile. Stage-discharge relationships will provide a basis for ramping rates by showing what change in depth is produced by what change in flow.

Dye studies should be used to give a preliminary estimate of travel time for a block of water from a release point, either the diversion structure or powerhouse, to each critical site. Dye studies should be conducted over a range of flows to evaluate the influence of discharge on travel time. These will provide a preliminary estimate of necessary duration of flow continuation at the powerhouse.

Data developed in these studies will be the basis for interim ramping rate recommendations. Additional studies, including test ramps with measurements of depth change at critical site transects, will be required once the facility is constructed. They will be the basis for operational ramping rates.

MONITORING

Monitoring of effects of flow regime (fish population response, attainment of flows, channel condition) will be required. The agencies may recommend changes in flow regime based upon results of monitoring.

REFERENCES

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INSTREAM FLOW STUDY GUIDELINES

APPENDIX 5/16/95 FALLBACK PREFERENCE CURVES

LIST OF TABLES

TABLE 1a. Substrate/cover codes and preferences

TABLE 2. Substrate/cover weighting for steelhead spawning.

TABLE 3. Substrate/cover weighting for trout or small charr (<20") spawning.

TABLE 4. Substrate/cover weighting for steelhead and trout fry.

TABLE 5. Substrate/cover weighting for steelhead juveniles and trout juveniles and adults.

TABLE 6. Substrate/cover weighting for steelhead adults.

TABLE 7. Substrate/cover weighting for salmon juveniles.

TABLE 8. Substrate/cover weighting for salmon spawning.

TABLE 9. Substrate/cover weighting for salmon adult holding.

TABLE 10. Weighting Factors for Ratios of Turbulent Plume to Calm, Deep Area in Plunge Pool Method

Table 11. Composite depth and velocity preferences for steelhead, rainbow, and cutthroat fry.

TABLE 12. Depth and velocity preferences of juvenile steelhead.

TABLE 13. Depth and velocity preferences of juvenile and adult rainbow trout (11 studies, 765 fish).

TABLE 14. Depth and velocity utilization and preference of steelhead spawning in the Cedar River (2 studies, 25 redds).

TABLE 15. Depth and velocity utilization and preference of resident rainbow trout spawning in tributaries to Packwood Lake (2 studies, 27 redds).

TABLE 16. Depth and velocity utilization and preference by adult resident cutthroat trout.

TABLE 17. Depth and velocity utilization and preference of juvenile coho salmon (4 studies, 451 fish).

TABLE 18. Depth and velocity utilization and preference of chinook salmon juveniles (4 studies, 173 fish).

TABLE 19. Depth and velocity preferences for juvenile and adult bull charr (39 fish, 4 studies).

TABLE 20. Depth and velocity preference for spawning bull charr (20 redds) in an east slope Cascades Mts. stream.

TABLE 21. Brook trout (brook charr) depth and velocity preferences in two southern Cascades Mountains streams (4 studies, 39 fish).

TABLE 22. Depth, velocity, and substrate preferences for spawning chum salmon in Kennedy Creek, Dosewallips and Duckabush rivers (2 studies, 20 redds).

TABLE 23. Depth, velocity, and substrate preferences for spawning pink salmon in Squire Creek, North Fork Stillaguamish, Dosewallips, and Duckabush rivers (studies, redds).

TABLE 24. Depth and velocity preferences for spawning sockeye salmon in the Cedar River (3 study reaches, 3 years, 1,037 redds).

Substrate/Cover preference curves and coding

Substrate codes in the following tables are in the form ab.c, where a is the dominant particle size (covers greatest bottom surface, not necessarily the largest diameter particle; e.g., sand may be dominant over cobble), b is the subdominant particle size, and c is tenths of cell area covered by dominant substrate type. Weighting factors in Table 2 are calculated from preference factors in Table 1 according to the following equation:

$$WF = 0.1 \times c \times PFa + 0.1 \times (1-c) \times PFb$$

where WF is the weighting factor, PFa is the preference factor for a in Table 1, and PFb is the preference factor for b in Table 1. Exceptions are noted by an asterisk; when subdominant is a "fine" and the criterion is for spawning, WF=0 when c=5 or less.

Table 1 lists codes 0 through 9, which are substrate categories, and codes 00.1 through 00.9, which are cover codes. Cover codes are redundant elements of the composite substrate code. For example, 00.1, 00.2, 00.3, 00.4, etc. all convey the same information: organic detritus is the only substrate type present. By convention, we have designated 00.9 as the only composite substrate code to be used to represent a substrate of nothing but organic detritus. Likewise, aa.9 is the code for a substrate of nothing but substrate type a.

TABLE 1. Substrate/cover codes and preferences

code		substrate/cover category		preference or weighting factor						
		<u>spawning</u>				<u>rearing/holding</u>				
		steel- head	bull charr	trout	salmon fry	juv salmon	trout adult	SH adult	salmon	
0	organic detritus/fine organic organic substrate	0.00	0.00	0.00	0.00		0.10	0.10	0.10	
00.1	undercut bank	----	----	----		1.00	1.00	1.00	1.00	
00.2	overhanging vegetation touching water	----	----	----			1.00	1.00	1.00	1.00
00.3	rootwad (including partly undercut)	----	----	----			1.00	1.00	1.00	1.00
00.4	log jam/submerged brush pile	----	----	----			1.00	1.00	1.00	1.00
00.5	log(s) parallel to bank	----	----	----			1.00	1.00	1.00	1.00
00.6	submerged aquatic vegetation	----	----	----			0.30	0.80	0.80	0.80
00.7	submerged terrestrial grass	----	----	----			1.00	1.00	0.80	0.60
00.8	overhead cover not touching water	----	----	----			0.40	0.10	0.20	0.10
00.9	fine organic substrate (see 0)	0.00	0.00	0.00	0.00		0.20		0.20	0.20
1	silt, clay	0.00	0.00	0.00		0.10	0.40	0.10	0.10	0.10
2	sand	0.00	0.00	0.00		0.10	0.40	0.10	0.10	0.10
3	small gravel (.1-5")		0.50	1.00	0.80	0.30	1.00	0.40	0.10	0.10
4	medium gravel (.5-1.5")		1.00	1.00	1.00	1.00	1.00	0.50	0.20	0.20
5	large gravel (1.5-3")		1.00	1.00	0.80	1.00	1.00	0.50	0.30	0.30
6	small cobble (3-6")		1.00	0.70	0.50	1.00	1.00	0.70	0.50	0.30
7	large cobble (6-12")		0.30	0.70	0.00	0.50	1.00	0.80	0.70	0.30
8	boulder (>12")	0.00	0.00	0.00	0.00		1.00	1.00	1.00	1.00
9	bedrock	0.00	0.00	0.00	0.00		0.10	0.30	0.30	0.30

TABLE 2. Substrate/cover weighting for steelhead spawning. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors steelhead spawning
00.0	0.00		
00.1	0.00		
00.2	0.00		
00.3	0.00		
00.4	0.00		
00.5	0.00		
00.6	0.00		
00.7	0.00		
00.8	0.00		
00.9	0.00	0.00	0.00
03.9	0.00	0.50	0.05
04.5	0.00	1.00	0.50
04.9	0.00	1.00	0.10
05.5	0.00	1.00	0.50
05.9	0.00	1.00	0.10
06.5	0.00	1.00	0.50
06.9	0.00	1.00	0.10
07.5	0.00	0.30	0.15
07.9	0.00	0.30	0.03
08.5	0.00	0.00	0.00
10.5	0.00	0.00	0.00
13.9	0.00	0.50	0.05
14.5	0.00	1.00	0.50
14.9	0.00	1.00	0.10
15.5	0.00	1.00	0.50
15.9	0.00	1.00	0.10
16.5	0.00	1.00	0.50
16.9	0.00	1.00	0.10
17.5	0.00	0.30	0.15
17.9	0.00	0.30	0.03
18.5	0.00	0.00	0.00
20.5	0.00	0.00	0.00
23.9	0.00	0.50	0.05
24.5	0.00	1.00	0.50
24.9	0.00	1.00	0.10
25.5	0.00	1.00	0.50
25.9	0.00	1.00	0.10

TABLE 2 continued.

Code	digit value	first digit value	second steelhead spawning	Weighting Factors
26.5		0.00	1.00	0.50
26.9		0.00	1.00	0.10
27.5		0.00	0.30	0.15
27.9		0.00	0.30	0.03
28.5		0.00	0.00	0.00
29.9		0.00	0.00	0.00
30.5		0.50	0.00	0.25
30.9		0.50	0.00	0.45
31.5		0.50	0.00	0.25
31.9		0.50	0.00	0.45
32.5		0.50	0.00	0.25
32.9		0.50	0.00	0.45
33.5 redundant	0.50	0.50	0.50	
33.9		0.50	0.50	0.50
34.5		0.50	1.00	0.75
34.9		0.50	1.00	0.55
35.5		0.50	1.00	0.75
35.9		0.50	1.00	0.55
36.5		0.50	1.00	0.75
36.9		0.50	1.00	0.55
37.5		0.50	0.30	0.40
37.9		0.50	0.30	0.48
38.5		0.50	0.00	0.25
38.9		0.50	0.00	0.45
39.5		0.50	0.00	0.25
39.9		0.50	0.00	0.45
40.5		1.00	0.00	0.50
40.9		1.00	0.00	0.90
41.5		1.00	0.00	0.50
41.9		1.00	0.00	0.90
42.5		1.00	0.00	0.50
42.9		1.00	0.00	0.90
43.5		1.00	0.50	0.75
43.9		1.00	0.50	0.95
44.5 redundant	1.00	1.00	1.00	
44.9		1.00	1.00	1.00
46.9		1.00	1.00	1.00
47.5		1.00	0.30	0.65
47.9		1.00	0.30	0.93
48.5		1.00	0.00	0.50

TABLE 2 continued.

Code	digit value	first digit value	second steelhead spawning	Weighting Factors
48.9		1.00	0.00	0.90
49.5		1.00	0.00	0.50
49.9		1.00	0.00	0.90
50.5		1.00	0.00	0.50
50.9		1.00	0.00	0.90
51.5		1.00	0.00	0.50
51.9		1.00	0.00	0.90
52.5		1.00	0.00	0.50
52.9		1.00	0.00	0.90
53.5		1.00	0.50	0.75
53.9		1.00	0.50	0.95
54.5		1.00	1.00	1.00
56.9		1.00	1.00	1.00
57.5		1.00	0.30	0.65
57.9		1.00	0.30	0.93
58.5		1.00	0.00	0.50
58.9		1.00	0.00	0.90
59.5		1.00	0.00	0.50
59.9		1.00	0.00	0.90
60.5		1.00	0.00	0.50
60.9		1.00	0.00	0.90
61.5		1.00	0.00	0.50
61.9		1.00	0.00	0.90
62.5		1.00	0.00	0.50
62.9		1.00	0.00	0.90
63.5		1.00	0.50	0.75
63.9		1.00	0.50	0.95
64.5		1.00	1.00	1.00
66.9		1.00	1.00	1.00
67.5		1.00	0.30	0.65
67.9		1.00	0.30	0.93
68.5		1.00	0.00	0.50
68.9		1.00	0.00	0.90
69.5		1.00	0.00	0.50
69.9		1.00	0.00	0.90
70.5		0.30	0.00	0.15
70.9		0.30	0.00	0.27
71.5		0.30	0.00	0.15
71.9		0.30	0.00	0.27
72.5		0.30	0.00	0.15

TABLE 2 continued.

Code	digit value	first digit value	second steelhead spawning	Weighting Factors
72.9		0.30	0.00	0.27
73.5		0.30	0.50	0.40
73.9		0.30	0.50	0.32
74.5		0.30	1.00	0.65
74.9		0.30	1.00	0.37
75.5		0.30	1.00	0.65
75.9		0.30	1.00	0.37
76.5		0.30	1.00	0.65
76.9		0.30	1.00	0.37
77.5 redundant	0.30	0.30	0.30	
77.9		0.30	0.30	0.30
78.5		0.30	0.00	0.15
78.9		0.30	0.00	0.27
79.5		0.30	0.00	0.15
79.9		0.30	0.00	0.27
80.5		0.00	0.00	0.00
82.9		0.00	0.00	0.00
83.5		0.00	0.50	0.25
83.9		0.00	0.50	0.05
84.5		0.00	1.00	0.50
84.9		0.00	1.00	0.10
85.5 redundant	0.00	1.00	0.50	
85.9		0.00	1.00	0.10
86.5		0.00	1.00	0.50
86.9		0.00	1.00	0.10
87.5		0.00	0.30	0.15
87.9		0.00	0.30	0.03
88.5		0.00	0.00	0.00
92.9		0.00	0.00	0.00
93.5		0.00	0.50	0.25
93.9		0.00	0.50	0.05
94.5		0.00	1.00	0.50
94.9		0.00	1.00	0.10
95.5		0.00	1.00	0.50
95.9		0.00	1.00	0.10
96.5		0.00	1.00	0.50
96.9		0.00	1.00	0.10
97.5		0.00	0.30	0.15
97.9		0.00	0.30	0.03
98.5		0.00	0.00	0.00
99.9		0.00	0.00	0.00

TABLE 3. Substrate/cover weighting for trout or small charr (<20") spawning. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	trout & charr spawning	Weighting Factors
00.0		0.00		
00.1		0.00		
00.2		0.00		
00.3		0.00		
00.4		0.00		
00.5		0.00		
00.6		0.00		
00.7		0.00		
00.8		0.00		
00.9		0.00		
02.9		0.00	0.00	0.00
03.9		0.00	0.80	0.00*
06.5		0.00	0.50	0.00*
06.9		0.00	0.50	0.00
10.5		0.00	0.00	0.00
13.9		0.00	1.00	0.00*
14.5		0.00	1.00	0.00
20.5		0.00	0.00	0.00
23.9		0.00	1.00	0.00*
26.9		0.00	0.50	0.00*
27.5		0.00	0.00	0.00
29.9		0.00	0.00	0.00
30.5		0.80	0.00	0.40
30.9		0.80	0.00	0.72
31.5		0.80	0.00	0.40

TABLE 3 continued.

Code	digit value	first digit value	second trout & charr spawning	Weighting Factors
31.9		0.80	0.00	0.72
32.5		0.80	0.00	0.40
32.9		0.80	0.00	0.72
33.5	redundant	0.80	0.80	0.80
33.9		0.80	0.80	0.80
34.5		0.80	1.00	0.90
34.9		0.80	1.00	0.82
35.5		0.80	0.80	0.80
35.9		0.80	0.80	0.80
36.5		0.80	0.50	0.65
36.9		0.80	0.50	0.77
37.5		0.80	0.00	0.40
37.9		0.80	0.00	0.72
38.5		0.80	0.00	0.40
38.9		0.80	0.00	0.72
39.5		0.80	0.00	0.40
39.9		0.80	0.00	0.72
40.5		1.00	0.00	0.50
40.9		1.00	0.00	0.90
41.5		1.00	0.00	0.50
41.9		1.00	0.00	0.90
42.5		1.00	0.00	0.50
42.9		1.00	0.00	0.90
43.5		1.00	0.80	0.90
43.9		1.00	0.80	0.98
44.9		1.00	1.00	1.00
45.5		1.00	0.80	0.90
45.9		1.00	0.80	0.98
46.5		1.00	0.50	0.75
46.9		1.00	0.50	0.95
47.5		1.00	0.00	0.50
47.9		1.00	0.00	0.90
48.5		1.00	0.00	0.50
48.9		1.00	0.00	0.90
49.5		1.00	0.00	0.50
49.9		1.00	0.00	0.90
50.5		0.80	0.00	0.40
50.9		0.80	0.00	0.72
51.5		0.80	0.00	0.40
51.9		0.80	0.00	0.72
52.5		0.80	0.00	0.40

TABLE 3 continued.

Code	digit value	first digit value	second trout & charr spawning	Weighting Factors
52.9		0.80	0.00	0.72
53.5		0.80	0.80	0.80
53.9		0.80	0.80	0.80
54.5		0.80	1.00	0.90
54.9		0.80	1.00	0.82
55.9		0.80	0.80	0.80
56.5		0.80	0.50	0.75
56.9		0.80	0.50	0.95
57.5		0.80	0.00	0.50
57.9		0.80	0.00	0.90
58.5		0.80	0.00	0.50
58.9		0.80	0.00	0.90
59.5		0.80	0.00	0.50
59.9		0.80	0.00	0.90
60.5		0.50	0.00	0.25
60.9		0.50	0.00	0.45
61.5		0.50	0.00	0.25
61.9		0.50	0.00	0.45
62.5		0.50	0.00	0.25
62.9		0.50	0.00	0.45
63.5		0.50	0.80	0.65
63.9		0.50	0.80	0.53
64.5		0.50	1.00	0.75
64.9		0.50	1.00	0.55
65.5		0.50	0.80	0.65
65.9		0.50	0.80	0.53
66.5 redundant	0.50	0.50	0.50	
66.9		0.50	0.50	0.50
67.5		0.50	0.00	0.25
67.9		0.50	0.00	0.45
68.5		0.50	0.00	0.25
68.9		0.50	0.00	0.45
69.5		0.50	0.00	0.25
69.9		0.50	0.00	0.45
70.5		0.00	0.00	0.00
72.9		0.00	0.00	0.00
73.5		0.00	0.80	0.40
73.9		0.00	0.80	0.08
74.5		0.00	1.00	0.50
74.9		0.00	1.00	0.10

TABLE 3 continued.

Code	digit value	first digit value	second trout & charr spawning	Weighting Factors
75.5		0.00	0.80	0.40
75.9		0.00	0.80	0.08
76.5		0.00	0.50	0.25
76.9		0.00	0.50	0.05
77.5 redundant	0.00	0.00	0.00	
77.9		0.00	0.00	0.00
82.9		0.00	0.00	0.00
83.5		0.00	0.80	0.40
83.9		0.00	0.80	0.08
84.5		0.00	1.00	0.50
84.9		0.00	1.00	0.10
85.5		0.00	0.80	0.40
85.9		0.00	0.80	0.08
86.5		0.00	0.50	0.25
86.9		0.00	0.50	0.05
87.5		0.00	0.00	0.00
92.9		0.00	0.00	0.00
93.5		0.00	1.00	0.00*
96.9		0.00	0.50	0.00*
97.5		0.00	0.00	0.00
99.9		0.00	0.00	0.00

TABLE 4. Substrate/cover weighting for steelhead and trout fry. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors steelhead & trout fry
00.0	0.10	0.10	
00.1			1.00
00.2		1.00	
00.3		1.00	
00.4		1.00	
00.5		0.30	
00.6		1.00	
00.7		0.40	
00.8		0.20	
00.9	0.10	0.10	0.10
03.9	0.10	1.00	0.19
04.5	0.10	1.00	0.55
04.9	0.10	1.00	0.19
05.5	0.10	1.00	0.55
05.9	0.10	1.00	0.19
06.5	0.10	1.00	0.55
06.9	0.10	1.00	0.19
07.5	0.10	1.00	0.55
07.9	0.10	1.00	0.19
08.5	0.10	1.00	0.55
08.9	0.10	1.00	0.19
09.5	0.10	0.10	0.10
09.9	0.10	0.10	0.10
10.5	0.10	0.10	0.10
13.9	0.10	1.00	0.19
14.5	0.10	1.00	0.55
14.9	0.10	1.00	0.19
15.5	0.10	1.00	0.55
15.9	0.10	1.00	0.19
16.5	0.10	1.00	0.55
16.9	0.10	1.00	0.19
17.5	0.10	1.00	0.55
17.9	0.10	1.00	0.19
18.5	0.10	1.00	0.55
18.9	0.10	1.00	0.19
19.5	0.10	0.10	0.10
19.9	0.10	0.10	0.10

TABLE 4 continued.

Code		first digit value	second digit value	Weighting Factors steelhead & trout fry
20.5		0.10	0.10	0.10
23.9		0.10	1.00	0.19
24.5		0.10	1.00	0.55
24.9		0.10	1.00	0.19
25.5		0.10	1.00	0.55
25.9		0.10	1.00	0.19
26.5		0.10	1.00	0.55
26.9		0.10	1.00	0.19
27.5		0.10	1.00	0.55
27.9		0.10	1.00	0.19
28.5		0.10	1.00	0.55
28.9		0.10	1.00	0.19
29.5		0.10	0.10	0.10
29.9		0.10	0.10	0.10
30.5		1.00	0.10	0.55
30.9		1.00	0.10	0.91
31.5		1.00	0.10	0.55
31.9		1.00	0.10	0.91
32.5		1.00	0.10	0.55
32.9		1.00	0.10	0.91
33.5	redundant 1.00	1.00	1.00	
33.9		1.00	1.00	1.00
38.9		1.00	1.00	1.00
39.5		1.00	0.10	0.55
39.9		1.00	0.10	0.91
40.5		1.00	0.10	0.55
40.9		1.00	0.10	0.91
41.5		1.00	0.10	0.55
41.9		1.00	0.10	0.91
42.5		1.00	0.10	0.55
42.9		1.00	0.10	0.91
43.5		1.00	1.00	1.00
48.9		1.00	1.00	1.00
49.5		1.00	0.10	0.55
49.9		1.00	0.10	0.91
50.5		1.00	0.10	0.55
50.9		1.00	0.10	0.91
51.5		1.00	0.10	0.55
51.9		1.00	0.10	0.91
52.5		1.00	0.10	0.55

TABLE 4 continued.

Code	first digit value	second digit value	Weighting Factors steelhead & trout fry
52.9	1.00	0.10	0.91
53.5	1.00	1.00	1.00
58.9	1.00	1.00	1.00
59.5	1.00	0.10	0.55
59.9	1.00	0.10	0.91
60.5	1.00	0.10	0.55
60.9	1.00	0.10	0.91
61.5	1.00	0.10	0.55
61.9	1.00	0.10	0.91
62.5	1.00	0.10	0.55
62.9	1.00	0.10	0.91
63.5	1.00	1.00	1.00
68.9	1.00	1.00	1.00
69.5	1.00	0.10	0.55
69.9	1.00	0.10	0.91
70.5	1.00	0.10	0.55
70.9	1.00	0.10	0.91
71.5	1.00	0.10	0.55
71.9	1.00	0.10	0.91
72.5	1.00	0.10	0.55
72.9	1.00	0.10	0.91
73.5	1.00	1.00	1.00
78.9	1.00	1.00	1.00
79.5	1.00	0.10	0.55
79.9	1.00	0.10	0.91
80.5	1.00	0.10	0.55
80.9	1.00	0.10	0.91
81.5	1.00	0.10	0.55
81.9	1.00	0.10	0.91
82.5	1.00	0.10	0.55
82.9	1.00	0.10	0.91
83.5	1.00	1.00	1.00
88.9	1.00	1.00	1.00
89.5	1.00	0.10	0.55
89.9	1.00	0.10	0.91
90.5	0.10	0.10	0.10
92.9	0.10	0.10	0.10
93.5	0.10	1.00	0.55
93.9	0.10	1.00	0.19
94.5	0.10	1.00	0.55

TABLE 4 continued.

Code	digit value	first digit value	second steelhead & trout fry	Weighting Factors
94.9		0.10	1.00	0.19
95.5		0.10	1.00	0.55
95.9		0.10	1.00	0.19
96.5		0.10	1.00	0.55
96.9		0.10	1.00	0.19
97.5		0.10	1.00	0.55
97.9		0.10	1.00	0.19
98.5		0.10	1.00	0.55
98.9		0.10	1.00	0.19
99.5 redundant	0.10	0.10	0.10	
99.9		0.10	0.10	0.10

TABLE 5. Substrate/cover weighting for steelhead juveniles and trout juveniles and adults. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors steelhead juveniles & trout juveniles & adults
00.0	0.10	0.10	
00.1		1.00	
00.2		1.00	
00.3		1.00	
00.4		1.00	
00.5		0.80	
00.6		0.80	
00.7		0.20	
00.8		0.20	
00.9	0.10	0.10	0.10
03.9	0.10	0.10	0.10
04.5	0.10	0.20	0.15
04.9	0.10	0.20	0.11
05.5	0.10	0.30	0.20
05.9	0.10	0.30	0.12
06.5	0.10	0.50	0.30
06.9	0.10	0.50	0.14
07.5	0.10	0.70	0.40
07.9	0.10	0.70	0.16
08.5	0.10	1.00	0.55
08.9	0.10	1.00	0.19
09.5	0.10	0.30	0.20
09.9	0.10	0.30	0.12
10.5	0.10	0.10	0.10
13.9	0.10	0.10	0.10
14.5	0.10	0.20	0.15
14.9	0.10	0.20	0.11
15.5	0.10	0.30	0.20
15.9	0.10	0.30	0.12
16.5	0.10	0.50	0.30
16.9	0.10	0.50	0.14
17.5	0.10	0.70	0.40
17.9	0.10	0.70	0.16
18.5	0.10	1.00	0.55
18.9	0.10	1.00	0.19
19.5	0.10	0.30	0.20

TABLE 5 continued.

Code	digit value	first digit value	second steelhead & trout juveniles & adults	Weighting Factors juveniles & adults
19.9		0.10	0.30	0.12
20.5		0.10	0.10	0.10
23.9		0.10	0.10	0.10
24.5		0.10	0.20	0.15
24.9		0.10	0.20	0.11
25.5		0.10	0.30	0.20
25.9		0.10	0.30	0.12
26.5		0.10	0.50	0.30
26.9		0.10	0.50	0.14
27.5		0.10	0.70	0.40
27.9		0.10	0.70	0.16
28.5		0.10	1.00	0.55
28.9		0.10	1.00	0.19
29.5		0.10	0.30	0.20
29.9		0.10	0.30	0.12
30.5		0.10	0.10	0.10
33.9		0.10	0.10	0.10
34.5		0.10	0.20	0.15
34.9		0.10	0.20	0.11
35.5		0.10	0.30	0.20
35.9		0.10	0.30	0.12
36.5		0.10	0.50	0.30
36.9		0.10	0.50	0.14
37.5		0.10	0.70	0.40
37.9		0.10	0.70	0.16
38.5		0.10	1.00	0.55
38.9		0.10	1.00	0.19
39.5		0.10	0.30	0.20
39.9		0.10	0.30	0.12
40.5		0.20	0.10	0.15
40.9		0.20	0.10	0.19
41.5		0.20	0.10	0.15
41.9		0.20	0.10	0.19
42.5		0.20	0.10	0.15
42.9		0.20	0.10	0.19
43.5		0.20	0.10	0.15
43.9		0.20	0.10	0.19
44.5 redundant	0.20	0.20	0.20	
44.9		0.20	0.20	0.20

TABLE 5 continued.

Code	digit value	first digit value	second steelhead & trout juveniles & adults	Weighting Factors juveniles & adults
45.5		0.20	0.30	0.25
45.9		0.20	0.30	0.21
46.5		0.20	0.50	0.35
46.9		0.20	0.50	0.23
47.5		0.20	0.70	0.45
47.9		0.20	0.70	0.25
48.5		0.20	1.00	0.60
48.9		0.20	1.00	0.28
49.5		0.20	0.30	0.25
49.9		0.20	0.30	0.21
50.5		0.30	0.10	0.20
50.9		0.30	0.10	0.28
51.5		0.30	0.10	0.20
51.9		0.30	0.10	0.28
52.5		0.30	0.10	0.20
52.9		0.30	0.10	0.28
53.5		0.30	0.10	0.20
53.9		0.30	0.10	0.28
54.5		0.30	0.20	0.25
54.9		0.30	0.20	0.29
55.5 redundant	0.30	0.30	0.30	
55.9		0.30	0.30	0.30
56.5		0.30	0.50	0.40
56.9		0.30	0.50	0.32
57.5		0.30	0.70	0.50
57.9		0.30	0.70	0.34
58.5		0.30	1.00	0.65
58.9		0.30	1.00	0.37
59.5		0.30	0.30	0.30
60.5		0.50	0.10	0.30
60.9		0.50	0.10	0.46
61.5		0.50	0.10	0.30
61.9		0.50	0.10	0.46
62.5		0.50	0.10	0.30
62.9		0.50	0.10	0.46
63.5		0.50	0.10	0.30
63.9		0.50	0.10	0.46
64.5		0.50	0.20	0.35
64.9		0.50	0.20	0.47

TABLE 5 continued.

Code	digit value	first digit value	second steelhead & trout juveniles & adults	Weighting Factors juveniles & adults
65.5		0.50	0.30	0.40
65.9		0.50	0.30	0.48
66.5 redundant	0.50	0.50	0.50	
66.9		0.50	0.50	0.50
67.5		0.50	0.70	0.60
67.9		0.50	0.70	0.52
68.5		0.50	1.00	0.75
68.9		0.50	1.00	0.55
69.5		0.50	0.30	0.40
69.9		0.50	0.30	0.48
70.5		0.70	0.10	0.40
70.9		0.70	0.10	0.64
71.5		0.70	0.10	0.40
71.9		0.70	0.10	0.64
72.5		0.70	0.10	0.40
72.9		0.70	0.10	0.64
73.5		0.70	0.10	0.40
73.9		0.70	0.10	0.64
74.5		0.70	0.20	0.45
74.9		0.70	0.20	0.65
75.5		0.70	0.30	0.50
75.9		0.70	0.30	0.66
76.5		0.70	0.50	0.60
76.9		0.70	0.50	0.68
77.5 redundant	0.70	0.70	0.70	
77.9		0.70	0.70	0.70
78.5		0.70	1.00	0.85
78.9		0.70	1.00	0.73
79.5		0.70	0.30	0.50
79.9		0.70	0.30	0.66
80.5		1.00	0.10	0.55
80.9		1.00	0.10	0.91
81.5		1.00	0.10	0.55
81.9		1.00	0.10	0.91
82.5		1.00	0.10	0.55
82.9		1.00	0.10	0.91
83.5		1.00	0.10	0.55
83.9		1.00	0.10	0.91
84.5		1.00	0.20	0.60

TABLE 5 continued.

Code	digit value	first digit value	second steelhead & trout juveniles & adults	Weighting Factors
84.9		1.00	0.20	0.92
85.5		1.00	0.30	0.65
85.9		1.00	0.30	0.93
86.5		1.00	0.50	0.75
86.9		1.00	0.50	0.95
87.5		1.00	0.70	0.85
87.9		1.00	0.70	0.97
88.5 redundant	1.00	1.00	1.00	
88.9		1.00	1.00	1.00
89.5		1.00	0.30	0.65
89.9		1.00	0.30	0.93
90.5		0.30	0.10	0.20
90.9		0.30	0.10	0.28
91.5		0.30	0.10	0.20
91.9		0.30	0.10	0.28
92.5		0.30	0.10	0.20
92.9		0.30	0.10	0.28
93.5		0.30	0.10	0.20
93.9		0.30	0.10	0.28
94.5		0.30	0.20	0.25
94.9		0.30	0.20	0.29
95.5		0.30	0.30	0.30
95.9		0.30	0.30	0.30
96.5		0.30	0.50	0.40
96.9		0.30	0.50	0.32
97.5		0.30	0.70	0.50
97.9		0.30	0.70	0.34
98.5		0.30	1.00	0.65
98.9		0.30	1.00	0.37
99.5 redundant	0.30	0.30	0.30	
99.9		0.30	0.30	0.30

TABLE 6. Substrate/cover weighting for steelhead adults. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	steelhead adults	Weighting Factors
00.0		0.10	0.10	
00.1				1.00
00.2				1.00
00.3				1.00
00.4				1.00
00.5				0.80
00.6				0.60
00.7				0.10
00.8				0.20
00.9	0.10	0.10	0.10	0.10
03.9	0.10	0.10	0.10	0.10
04.5	0.10	0.20	0.15	0.15
04.9	0.10	0.20	0.11	0.11
05.5	0.10	0.30	0.20	0.20
05.9	0.10	0.30	0.12	0.12
06.5	0.10	0.30	0.20	0.20
06.9	0.10	0.30	0.12	0.12
07.5	0.10	0.30	0.20	0.20
07.9	0.10	0.30	0.12	0.12
08.5	0.10	1.00	0.55	0.55
08.9	0.10	1.00	0.19	0.19
09.5	0.10	0.30	0.20	0.20
09.9	0.10	0.30	0.12	0.12
10.5	0.10	0.10	0.10	0.10
13.9	0.10	0.10	0.10	0.10
14.5	0.10	0.20	0.15	0.15
14.9	0.10	0.20	0.11	0.11
15.5	0.10	0.30	0.20	0.20
15.9	0.10	0.30	0.12	0.12
16.5	0.10	0.30	0.20	0.20
16.9	0.10	0.30	0.12	0.12
17.5	0.10	0.30	0.20	0.20
17.9	0.10	0.30	0.12	0.12
18.5	0.10	1.00	0.55	0.55
18.9	0.10	1.00	0.19	0.19
19.5	0.10	0.30	0.20	0.20
19.9	0.10	0.30	0.12	0.12

TABLE 6 continued.

Code	digit value	first digit value	second steelhead adults	Weighting Factors
20.5		0.10	0.10	0.10
23.9		0.10	0.10	0.10
24.5		0.10	0.20	0.15
24.9		0.10	0.20	0.11
25.5		0.10	0.30	0.20
25.9		0.10	0.30	0.12
26.5		0.10	0.30	0.20
26.9		0.10	0.30	0.12
27.5		0.10	0.30	0.20
27.9		0.10	0.30	0.12
28.5		0.10	1.00	0.55
28.9		0.10	1.00	0.19
29.5		0.10	0.30	0.20
29.9		0.10	0.30	0.12
30.5		0.10	0.10	0.10
30.9		0.10	0.10	0.10
31.5		0.10	0.10	0.10
31.9		0.10	0.10	0.10
32.5		0.10	0.10	0.10
32.9		0.10	0.10	0.10
33.9		0.10	0.10	0.10
34.5		0.10	0.20	0.15
34.9		0.10	0.20	0.11
35.5		0.10	0.30	0.20
35.9		0.10	0.30	0.12
36.5		0.10	0.30	0.20
36.9		0.10	0.30	0.12
37.5		0.10	0.30	0.20
37.9		0.10	0.30	0.12
38.5		0.10	1.00	0.55
38.9		0.10	1.00	0.19
39.5		0.10	0.30	0.20
39.9		0.10	0.30	0.12
40.5		0.20	0.10	0.15
40.9		0.20	0.10	0.19
41.5		0.20	0.10	0.15
41.9		0.20	0.10	0.19
42.5		0.20	0.10	0.15
42.9		0.20	0.10	0.19
43.5		0.20	0.10	0.15

TABLE 6 continued.

Code	digit value	first digit value	second steelhead adults	Weighting Factors
43.9		0.20	0.10	0.19
44.5 redundant	0.20	0.20	0.20	
44.9		0.20	0.20	0.20
45.5		0.20	0.30	0.25
45.9		0.20	0.30	0.21
46.5		0.20	0.30	0.25
46.9		0.20	0.30	0.21
47.5		0.20	0.30	0.25
47.9		0.20	0.30	0.21
48.5		0.20	1.00	0.60
48.9		0.20	1.00	0.28
49.5		0.20	0.30	0.25
49.9		0.20	0.30	0.21
50.5		0.30	0.10	0.20
50.9		0.30	0.10	0.28
51.5		0.30	0.10	0.20
51.9		0.30	0.10	0.28
52.5		0.30	0.10	0.20
52.9		0.30	0.10	0.28
53.5		0.30	0.10	0.20
53.9		0.30	0.10	0.28
54.5		0.30	0.20	0.25
54.9		0.30	0.20	0.29
55.5 redundant	0.30	0.30	0.30	
55.9		0.30	0.30	0.30
57.9		0.30	0.30	0.30
58.5		0.30	1.00	0.65
58.9		0.30	1.00	0.37
59.5		0.30	0.30	0.30
59.9		0.30	0.30	0.30
60.5		0.30	0.10	0.20
60.9		0.30	0.10	0.28
61.5		0.30	0.10	0.20
61.9		0.30	0.10	0.28
62.5		0.30	0.10	0.20
62.9		0.30	0.10	0.28
63.5		0.30	0.10	0.20
63.9		0.30	0.10	0.28
64.5		0.30	0.20	0.25
64.9		0.30	0.20	0.29

TABLE 6 continued.

Code	digit value	first digit value	second steelhead adults	Weighting Factors
65.5		0.30	0.30	0.30
67.9		0.30	0.30	0.30
68.5		0.30	1.00	0.65
68.9		0.30	1.00	0.37
69.5		0.30	0.30	0.30
69.9		0.30	0.30	0.30
70.5		0.30	0.10	0.20
70.9		0.30	0.10	0.28
71.5		0.30	0.10	0.20
71.9		0.30	0.10	0.28
72.5		0.30	0.10	0.20
72.9		0.30	0.10	0.28
73.5		0.30	0.10	0.20
73.9		0.30	0.10	0.28
74.5		0.30	0.20	0.25
74.9		0.30	0.20	0.29
75.5		0.30	0.30	0.30
77.9		0.30	0.30	0.30
78.5		0.30	1.00	0.65
78.9		0.30	1.00	0.37
79.5		0.30	0.30	0.30
79.9		0.30	0.30	0.30
80.5		1.00	0.10	0.55
80.9		1.00	0.10	0.91
81.5		1.00	0.10	0.55
81.9		1.00	0.10	0.91
82.5		1.00	0.10	0.55
82.9		1.00	0.10	0.91
83.5		1.00	0.10	0.55
83.9		1.00	0.10	0.91
84.5		1.00	0.20	0.60
84.9		1.00	0.20	0.92
85.5		1.00	0.30	0.65
85.9		1.00	0.30	0.93
86.5		1.00	0.30	0.65
86.9		1.00	0.30	0.93
87.5		1.00	0.30	0.65
87.9		1.00	0.30	0.93
88.5 redundant	1.00	1.00	1.00	
88.9		1.00	1.00	1.00

TABLE 6 continued.

Code	digit value	first digit value	second steelhead adults	Weighting Factors
89.5		1.00	0.30	0.65
89.9		1.00	0.30	0.93
90.5		0.30	0.10	0.20
90.9		0.30	0.10	0.28
91.5		0.30	0.10	0.20
91.9		0.30	0.10	0.28
92.5		0.30	0.10	0.20
92.9		0.30	0.10	0.28
93.5		0.30	0.10	0.20
93.9		0.30	0.10	0.28
94.5		0.30	0.20	0.25
94.9		0.30	0.20	0.29
95.5		0.30	0.30	0.30
97.9		0.30	0.30	0.30
98.5		0.30	1.00	0.65
98.9		0.30	1.00	0.37
99.5 redundant	0.30	0.30	0.30	
99.9		0.30	0.30	0.30

TABLE 7. Substrate/cover weighting for salmon juveniles. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors salmon juveniles
00.0	0.10	0.10	
00.1			1.00
00.2			1.00
00.3			1.00
00.4			1.00
00.5			0.80
00.6			1.00
00.7			0.10
00.8			
00.9	0.10	0.10	0.10
03.9	0.10	0.10	0.10
04.5	0.10	0.30	0.20
04.9	0.10	0.30	0.12
05.5	0.10	0.30	0.20
05.9	0.10	0.30	0.12
06.5	0.10	0.50	0.30
06.9	0.10	0.50	0.14
07.5	0.10	0.70	0.40
07.9	0.10	0.70	0.16
08.5	0.10	1.00	0.55
08.9	0.10	1.00	0.19
09.5	0.10	0.30	0.20
09.9	0.10	0.30	0.12
10.5	0.10	0.10	0.10
13.9	0.10	0.10	0.10
14.5	0.10	0.30	0.20
14.9	0.10	0.30	0.12
15.5	0.10	0.30	0.20
15.9	0.10	0.30	0.12
16.5	0.10	0.50	0.30
16.9	0.10	0.50	0.14
17.5	0.10	0.70	0.40
17.9	0.10	0.70	0.16
18.5	0.10	1.00	0.55
18.9	0.10	1.00	0.19
19.5	0.10	0.30	0.20
19.9	0.10	0.30	0.12
20.5	0.10	0.10	0.10
23.9	0.10	0.10	0.10
24.5	0.10	0.30	0.20
24.9	0.10	0.30	0.12
25.5	0.10	0.30	0.20
25.9	0.10	0.30	0.12
26.5	0.10	0.50	0.30
26.9	0.10	0.50	0.14

TABLE 7 continued.

Code first second Weighting Factors
 digit digit salmon
 value value juveniles

27.5	0.10	0.70	0.40
27.9	0.10	0.70	0.16
28.5	0.10	1.00	0.55
28.9	0.10	1.00	0.19
29.5	0.10	0.30	0.20
29.9	0.10	0.30	0.12
30.5	0.10	0.10	0.10
33.9	0.10	0.10	0.10
34.5	0.10	0.30	0.20
34.9	0.10	0.30	0.12
35.5	0.10	0.30	0.20
35.9	0.10	0.30	0.12
36.5	0.10	0.50	0.30
36.9	0.10	0.50	0.14
37.5	0.10	0.70	0.40
37.9	0.10	0.70	0.16
38.5	0.10	1.00	0.55
38.9	0.10	1.00	0.19
39.5	0.10	0.30	0.20
39.9	0.10	0.30	0.12
40.5	0.30	0.10	0.20
40.9	0.30	0.10	0.28
41.5	0.30	0.10	0.20
41.9	0.30	0.10	0.28
42.5	0.30	0.10	0.20
42.9	0.30	0.10	0.28
43.5	0.30	0.10	0.20
43.9	0.30	0.10	0.28
44.5	redundant	0.30	0.30
44.9	0.30	0.30	0.30
45.9	0.30	0.30	0.30
46.5	0.30	0.50	0.40
46.9	0.30	0.50	0.32
47.5	0.30	0.70	0.50
47.9	0.30	0.70	0.34
48.5	0.30	1.00	0.65
48.9	0.30	1.00	0.37
49.5	0.30	0.30	0.30
49.9	0.30	0.30	0.30
50.5	0.30	0.10	0.20
50.9	0.30	0.10	0.28
51.5	0.30	0.10	0.20
51.9	0.30	0.10	0.28
52.5	0.30	0.10	0.20
52.9	0.30	0.10	0.28
53.5	0.30	0.10	0.20
53.9	0.30	0.10	0.28
54.5	0.30	0.30	0.30
55.9	0.30	0.30	0.30

TABLE 7 continued.

Code first second Weighting Factors
 digit digit salmon
 value value juveniles

56.5	0.30	0.50	0.40	
56.9	0.30	0.50	0.32	
57.5	0.30	0.70	0.50	
57.9	0.30	0.70	0.34	
58.5	0.30	1.00	0.65	
58.9	0.30	1.00	0.37	
59.5	0.30	0.30	0.30	
59.9	0.30	0.30	0.30	
60.5	0.50	0.10	0.30	
60.9	0.50	0.10	0.46	
61.5	0.50	0.10	0.30	
61.9	0.50	0.10	0.46	
62.5	0.50	0.10	0.30	
62.9	0.50	0.10	0.46	
63.5	0.50	0.10	0.30	
63.9	0.50	0.10	0.46	
64.5	0.50	0.30	0.40	
64.9	0.50	0.30	0.48	
65.5	0.50	0.30	0.40	
65.9	0.50	0.30	0.48	
66.5	redundant	0.50	0.50	0.50
66.9	0.50	0.50	0.50	
67.5	0.50	0.70	0.60	
67.9	0.50	0.70	0.52	
68.5	0.50	1.00	0.75	
68.9	0.50	1.00	0.55	
69.5	0.50	0.30	0.40	
69.9	0.50	0.30	0.48	
70.5	0.70	0.10	0.40	
70.9	0.70	0.10	0.64	
71.5	0.70	0.10	0.40	
71.9	0.70	0.10	0.64	
72.5	0.70	0.10	0.40	
72.9	0.70	0.10	0.64	
73.5	0.70	0.10	0.40	
73.9	0.70	0.10	0.64	
74.5	0.70	0.30	0.50	
74.9	0.70	0.30	0.66	
75.5	0.70	0.30	0.50	
75.9	0.70	0.30	0.66	
76.5	0.70	0.50	0.60	
76.9	0.70	0.50	0.68	
77.5	redundant	0.70	0.70	0.70
77.9	0.70	0.70	0.70	
78.5	0.70	1.00	0.85	
78.9	0.70	1.00	0.73	
79.5	0.70	0.30	0.50	
79.9	0.70	0.30	0.66	
80.5	1.00	0.10	0.55	

TABLE 7 continued.

Code first second Weighting Factors
 digit digit salmon
 value value juveniles

80.9	1.00	0.10	0.91
81.5	1.00	0.10	0.55
81.9	1.00	0.10	0.91
82.5	1.00	0.10	0.55
82.9	1.00	0.10	0.91
83.5	1.00	0.10	0.55
83.9	1.00	0.10	0.91
84.5	1.00	0.30	0.65
84.9	1.00	0.30	0.93
85.5	1.00	0.30	0.65
85.9	1.00	0.30	0.93
86.5	1.00	0.50	0.75
86.9	1.00	0.50	0.95
87.5	1.00	0.70	0.85
87.9	1.00	0.70	0.97
88.5 redundant	1.00	1.00	1.00
88.9	1.00	1.00	1.00
89.5	1.00	0.30	0.65
89.9	1.00	0.30	0.93
90.5	0.30	0.10	0.20
90.9	0.30	0.10	0.28
91.5	0.30	0.10	0.20
91.9	0.30	0.10	0.28
92.5	0.30	0.10	0.20
92.9	0.30	0.10	0.28
93.5	0.30	0.10	0.20
93.9	0.30	0.10	0.28
94.5	0.30	0.30	0.30
95.9	0.30	0.30	0.30
96.5	0.30	0.50	0.40
96.9	0.30	0.50	0.32
97.5	0.30	0.70	0.50
97.9	0.30	0.70	0.34
98.5	0.30	1.00	0.65
98.9	0.30	1.00	0.37
99.5 redundant	0.30	0.30	0.30
99.9	0.30	0.30	0.30

TABLE 8. Substrate/cover weighting for salmon spawning. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors salmon spawning
00.0	0.10	0.10	
00.1			
00.2			
00.3			
00.4			
00.5			
00.6			
00.7			
00.8			
00.9	0.00	0.00	0.00
03.9	0.00	0.30	0.03
04.5	0.00	1.00	0.50
04.9	0.00	1.00	0.10
05.5	0.00	1.00	0.50
05.9	0.00	1.00	0.10
06.5	0.00	1.00	0.50
06.9	0.00	1.00	0.10
07.5	0.00	0.30	0.15
07.9	0.00	0.30	0.03
08.5	0.00	0.00	0.00
10.5	0.00	0.00	0.00
13.9	0.00	0.30	0.03
14.5	0.00	1.00	0.50
14.9	0.00	1.00	0.10
15.5	0.00	1.00	0.50
15.9	0.00	1.00	0.10
16.5	0.00	1.00	0.50
16.9	0.00	1.00	0.10
17.5	0.00	0.30	0.15
17.9	0.00	0.30	0.03
18.5	0.00	0.00	0.00
20.5	0.00	0.00	0.00
23.9	0.00	0.30	0.03
24.5	0.00	1.00	0.50
24.9	0.00	1.00	0.10
25.5	0.00	1.00	0.50
25.9	0.00	1.00	0.10
26.5	0.00	1.00	0.50
26.9	0.00	1.00	0.10
27.5	0.00	0.30	0.15
27.9	0.00	0.30	0.03
28.5	0.00	0.00	0.00
29.9	0.00	0.00	0.00
30.5	0.30	0.00	0.15
30.9	0.30	0.00	0.27

TABLE 8 continued.

Code first second Weighting Factors
 digit digit salmon
 value value spawning

31.5	0.30	0.00	0.15
31.9	0.30	0.00	0.27
32.5	0.30	0.00	0.15
32.9	0.30	0.00	0.27
33.5	redundant	0.30	0.30 0.30
33.9	0.30	0.30	0.30
34.5	0.30	1.00	0.65
34.9	0.30	1.00	0.37
35.5	0.30	1.00	0.65
35.9	0.30	1.00	0.37
36.5	0.30	1.00	0.65
36.9	0.30	1.00	0.37
37.5	0.30	0.30	0.30
37.9	0.30	0.30	0.30
38.5	0.30	0.00	0.15
38.9	0.30	0.00	0.27
39.5	0.30	0.00	0.15
39.9	0.30	0.00	0.27
40.5	1.00	0.00	0.50
40.9	1.00	0.00	0.90
41.5	1.00	0.00	0.50
41.9	1.00	0.00	0.90
42.5	1.00	0.00	0.50
42.9	1.00	0.00	0.90
43.5	1.00	0.30	0.65
43.9	1.00	0.30	0.93
44.5	redundant	1.00	1.00 1.00
44.9	1.00	1.00	1.00
46.9	1.00	1.00	1.00
47.5	1.00	0.30	0.65
47.9	1.00	0.30	0.93
48.5	1.00	0.00	0.50
48.9	1.00	0.00	0.90
49.5	1.00	0.00	0.50
49.9	1.00	0.00	0.90
50.5	1.00	0.00	0.50
50.9	1.00	0.00	0.90
51.5	1.00	0.00	0.50
51.9	1.00	0.00	0.90
52.5	1.00	0.00	0.50
52.9	1.00	0.00	0.90
53.5	1.00	0.30	0.65
53.9	1.00	0.30	0.93
54.5	1.00	1.00	1.00
56.9	1.00	1.00	1.00
57.5	1.00	0.30	0.65
57.9	1.00	0.30	0.93
58.5	1.00	0.00	0.50
58.9	1.00	0.00	0.90

TABLE 8 continued.

Code	first digit value	second digit value	Weighting Factors salmon spawning
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59.5	1.00	0.00	0.50
59.9	1.00	0.00	0.90
60.5	1.00	0.00	0.50
60.9	1.00	0.00	0.90
61.5	1.00	0.00	0.50
61.9	1.00	0.00	0.90
62.5	1.00	0.00	0.50
62.9	1.00	0.00	0.90
63.5	1.00	0.30	0.65
63.9	1.00	0.30	0.93
64.5	1.00	1.00	1.00
66.9	1.00	1.00	1.00
67.5	1.00	0.30	0.65
67.9	1.00	0.30	0.93
68.5	1.00	0.00	0.50
68.9	1.00	0.00	0.90
69.5	1.00	0.00	0.50
69.9	1.00	0.00	0.90
70.5	0.30	0.00	0.15
70.9	0.30	0.00	0.27
71.5	0.30	0.00	0.15
71.9	0.30	0.00	0.27
72.5	0.30	0.00	0.15
72.9	0.30	0.00	0.27
73.5	0.30	0.30	0.30
73.9	0.30	0.30	0.30
74.5	0.30	1.00	0.65
74.9	0.30	1.00	0.37
75.5	0.30	1.00	0.65
75.9	0.30	1.00	0.37
76.5	0.30	1.00	0.65
76.9	0.30	1.00	0.37
77.5	redundant	0.30	0.30 0.30
77.9	0.30	0.30	0.30
78.5	0.30	0.00	0.15
78.9	0.30	0.00	0.27
79.5	0.30	0.00	0.15
79.9	0.30	0.00	0.27
80.5	0.00	0.00	0.00
82.9	0.00	0.00	0.00
83.5	0.00	0.30	0.15
83.9	0.00	0.30	0.03
84.5	0.00	1.00	0.50
84.9	0.00	1.00	0.10
85.5	0.00	1.00	0.50
85.9	0.00	1.00	0.10
86.5	0.00	1.00	0.50
86.9	0.00	1.00	0.10
87.5	0.00	0.30	0.15

TABLE 8 continued.

Code	first digit value	second digit value	Weighting Factors salmon spawning
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87.9	0.00	0.30	0.03
88.5 redundant	0.00	0.00	0.00
88.9	0.00	0.00	0.00
92.9	0.00	0.00	0.00
93.5	0.00	0.30	0.15
93.9	0.00	0.30	0.03
94.5	0.00	1.00	0.50
94.9	0.00	1.00	0.10
95.5	0.00	1.00	0.50
95.9	0.00	1.00	0.10
96.5	0.00	1.00	0.50
96.9	0.00	1.00	0.10
97.5	0.00	0.30	0.15
97.9	0.00	0.30	0.03
98.5	0.00	0.00	0.00
99.9	0.00	0.00	0.00

TABLE 9. Substrate/cover weighting for salmon adult holding. Assume straight line between coordinates. Values derived from Table 1 as in text. Asterisk indicates deviation from calculation.

Code	first digit value	second digit value	Weighting Factors salmon adult holding
00.0	0.10	0.10	
00.1			1.00
00.2			1.00
00.3			1.00
00.4			1.00
00.5			0.80
00.6			0.80
00.7			0.10
00.8			
00.9	0.10	0.10	0.10
03.9	0.10	0.10	0.10
04.5	0.10	0.30	0.20
04.9	0.10	0.30	0.12
05.5	0.10	0.30	0.20
05.9	0.10	0.30	0.12
06.5	0.10	0.30	0.20
06.9	0.10	0.30	0.12
07.5	0.10	0.30	0.20
07.9	0.10	0.30	0.12
08.5	0.10	1.00	0.55
08.9	0.10	1.00	0.19

TABLE 9 continued.

Code	first digit value	second digit value	Weighting Factors salmon adult holding
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09.5	0.10	0.30	0.20
09.9	0.10	0.30	0.12
10.5	0.10	0.10	0.10
13.9	0.10	0.10	0.10
14.5	0.10	0.30	0.20
14.9	0.10	0.30	0.12
15.5	0.10	0.30	0.20
15.9	0.10	0.30	0.12
16.5	0.10	0.30	0.20
16.9	0.10	0.30	0.12
17.5	0.10	0.30	0.20
17.9	0.10	0.30	0.12
18.5	0.10	1.00	0.55
18.9	0.10	1.00	0.19
19.5	0.10	0.30	0.20
19.9	0.10	0.30	0.12
20.5	0.10	0.10	0.10
23.9	0.10	0.10	0.10
24.5	0.10	0.30	0.20
24.9	0.10	0.30	0.12
25.5	0.10	0.30	0.20
25.9	0.10	0.30	0.12
26.5	0.10	0.30	0.20
26.9	0.10	0.30	0.12
27.5	0.10	0.30	0.20
27.9	0.10	0.30	0.12
28.5	0.10	1.00	0.55
28.9	0.10	1.00	0.19
29.5	0.10	0.30	0.20
29.9	0.10	0.30	0.12
30.5	0.10	0.10	0.10
33.9	0.10	0.10	0.10
34.5	0.10	0.30	0.20
34.9	0.10	0.30	0.12
35.5	0.10	0.30	0.20
35.9	0.10	0.30	0.12
36.5	0.10	0.30	0.20
36.9	0.10	0.30	0.12
37.5	0.10	0.30	0.20
37.9	0.10	0.30	0.12
38.5	0.10	1.00	0.55
38.9	0.10	1.00	0.19
39.5	0.10	0.30	0.20
39.9	0.10	0.30	0.12
40.5	0.30	0.10	0.20
40.9	0.30	0.10	0.28
41.5	0.30	0.10	0.20
41.9	0.30	0.10	0.28
42.5	0.30	0.10	0.20

TABLE 9 continued.

Code	first digit value	second digit value	Weighting Factors salmon adult holding
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42.9	0.30	0.10	0.28
43.5	0.30	0.10	0.20
43.9	0.30	0.10	0.28
44.5 redundant	0.30	0.30	0.30
44.9	0.30	0.30	0.30
47.9	0.30	0.30	0.30
48.5	0.30	1.00	0.65
48.9	0.30	1.00	0.37
49.5	0.30	0.30	0.30
49.9	0.30	0.30	0.30
50.5	0.30	0.10	0.20
50.9	0.30	0.10	0.28
51.5	0.30	0.10	0.20
51.9	0.30	0.10	0.28
52.5	0.30	0.10	0.20
52.9	0.30	0.10	0.28
53.5	0.30	0.10	0.20
53.9	0.30	0.10	0.28
54.5	0.30	0.30	0.30
57.9	0.30	0.30	0.30
58.5	0.30	1.00	0.65
58.9	0.30	1.00	0.37
59.5	0.30	0.30	0.30
59.9	0.30	0.30	0.30
60.5	0.30	0.10	0.20
60.9	0.30	0.10	0.28
61.5	0.30	0.10	0.20
61.9	0.30	0.10	0.28
62.5	0.30	0.10	0.20
62.9	0.30	0.10	0.28
63.5	0.30	0.10	0.20
63.9	0.30	0.10	0.28
64.5	0.30	0.30	0.30
67.9	0.30	0.30	0.30
68.5	0.30	1.00	0.65
68.9	0.30	1.00	0.37
69.5	0.30	0.30	0.30
69.9	0.30	0.30	0.30
70.5	0.30	0.10	0.20
70.9	0.30	0.10	0.28
71.5	0.30	0.10	0.20
71.9	0.30	0.10	0.28
72.5	0.30	0.10	0.20
72.9	0.30	0.10	0.28
73.5	0.30	0.10	0.20
73.9	0.30	0.10	0.28
74.5	0.30	0.30	0.30
77.9	0.30	0.30	0.30
78.5	0.30	1.00	0.65

TABLE 9 continued.

Code	first digit value	second digit value	Weighting Factors salmon adult holding
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78.9	0.30	1.00	0.37
79.5	0.30	0.30	0.30
79.9	0.30	0.30	0.30
80.5	1.00	0.10	0.55
80.9	1.00	0.10	0.91
81.5	1.00	0.10	0.55
81.9	1.00	0.10	0.91
82.5	1.00	0.10	0.55
82.9	1.00	0.10	0.91
83.5	1.00	0.10	0.55
83.9	1.00	0.10	0.91
84.5	1.00	0.30	0.65
84.9	1.00	0.30	0.93
85.5	1.00	0.30	0.65
85.9	1.00	0.30	0.93
86.5	1.00	0.30	0.65
86.9	1.00	0.30	0.93
87.5	1.00	0.30	0.65
87.9	1.00	0.30	0.93
88.5 redundant	1.00	1.00	1.00
88.9	1.00	1.00	1.00
89.5	1.00	0.30	0.65
89.9	1.00	0.30	0.93
90.5	0.30	0.10	0.20
90.9	0.30	0.10	0.28
91.5	0.30	0.10	0.20
91.9	0.30	0.10	0.28
92.5	0.30	0.10	0.20
92.9	0.30	0.10	0.28
93.5	0.30	0.10	0.20
93.9	0.30	0.10	0.28
94.5	0.30	0.30	0.30
97.9	0.30	0.30	0.30
98.5	0.30	1.00	0.65
98.9	0.30	1.00	0.37
99.5 redundant	0.30	0.30	0.30
99.9	0.30	0.30	0.30

TABLE 10. Weighting Factors for Ratios of Turbulent Plume to Calm, Deep Area in Plunge Pool Method

Ratio (plume/calm, deep)	Weighting Factor
0	0.1
0.25	0.4
0.5	0.8
1.0	1.0
2.0	0.5
4.0	0.25
8.0	0.125
16.0	0.06
32.0	0.03

Depth and velocity preference curves

Depth and velocity preference curves are listed below. They are being revised continually as new data are obtained and analyzed. Please contact the Department of Fish and Wildlife for the most recent preference curves for salmon, trout, and other game fish.

Table 11. Composite depth and velocity preferences for steelhead, rainbow, and cutthroat fry.

depth interval (feet)	depth composite preference (3 studies, 175 fish)	recommended depth preference
0.00-0.09	0.00	0.00
0.10-0.19	0.90	0.90
0.20-0.69	1.00	1.00
0.70-1.09	0.12	0.30
1.10-1.39	0.03	0.30
1.40-1.99	0.27	0.30
2.00-2.69	0.41	0.30
2.70-4.99	0.29	0.30
5.00+	0.01	0.01

TABLE 11. trout fry - continued

velocity interval (feet/second)	composite preference (8 studies, 1098 fish)	recommended velocity preference
0.00-0.09	0.55	0.55
0.10-0.19	1.00	1.00
0.20-0.29	0.60	
0.30-0.39	0.47	
0.40-0.59	0.60	0.60
0.60-0.69	0.64	
0.70-0.79	0.40	
0.80-0.89	0.17	
0.90-0.99	0.21	0.20
1.00-1.09	0.39	
1.10-1.19	0.71	
1.20-1.29	0.54	
1.30-1.39	0.55	
1.40-1.49	0.43	
1.50-1.69	0.42	
1.70-1.79	0.41	
1.80-3.29	0.51	
3.30+	0.51	0.00

TABLE 12. Depth and velocity preferences of juvenile steelhead.

depth interval (feet)	depth composite preference (10 studies, 913 fish)	recommended depth preference
0.00-0.49	0.00	0.00
0.50-0.59	0.03	0.03
0.60-0.69	0.04	
0.70-0.79	0.07	0.07
0.80-0.89	0.11	
0.90-0.99	0.10	0.11
1.00-1.09	0.24	
1.10-1.29	0.26	0.25
1.30-1.49	0.30	
1.50-1.59	0.32	
1.60-1.69	0.37	0.35
1.70-1.89	0.39	
1.90-1.99	0.41	0.40
2.00-2.09	0.69	
2.10-2.19	0.65	0.65
2.20-2.49	0.84	0.85
2.50-2.59	0.89	0.90
2.60-2.99	1.00	1.00
3.00-3.19	0.80	
3.20-3.39	0.79	
3.40-3.99	0.86	0.86
4.00-4.49	0.69	
4.50+	0.64	0.64

TABLE 12. steelhead parr - continued

velocity interval (feet/second)	composite preference (12 studies, 962 fish)	recommended velocity preference coordinates
0.00-0.09	0.23	0.23
0.10-0.19	0.26	
0.20-0.29	0.32	0.30
0.30-0.39	0.29	
0.40-0.49	0.43	
0.50-0.59	0.50	0.50
0.60-0.69	0.60	
0.70-0.79	0.65	
0.80-0.89	0.81	
0.90-0.99	0.78	0.80
1.00-1.09	0.85	
1.10-1.19	0.72	
1.20-1.29	0.74	
1.30-1.39	1.00	1.00
1.40-1.49	0.99	
1.50-1.59	0.97	0.97
1.60-1.69	0.81	
1.70-1.89	0.77	
1.90-1.99	0.75	
2.00-2.09	0.66	
2.10-2.19	0.71	
2.20-2.29	0.93	
2.30-2.39	0.92	
2.40-2.59	0.91	0.80
2.60-2.69	0.71	
2.70-2.79	0.64	
2.80-2.89	0.61	0.60
2.90-2.99	0.39	
3.00-3.19	0.38	0.35
3.20-3.49	0.34	
3.50-3.59	0.28	
3.60-3.69	0.22	0.22
3.70-4.99	0.19	0.19
5.00-5.99	0.16	0.16
6.00+		0.00

TABLE 13. Depth and velocity preferences of juvenile and adult rainbow trout (11 studies, 765 fish).

depth interval (feet)	depth composite preference	recommended depth preference coordinates
0.00-0.49	0.03	0.00
0.50-0.59	0.03	0.00
0.60-0.79	0.08	
0.80-0.89	0.09	0.09
0.90-0.99	0.15	0.15
1.00-1.09	0.23	0.23
1.10-1.19	0.26	
1.20-1.29	0.42	
1.30-1.39	0.47	0.45
1.40-1.49	0.50	
1.50-1.59	0.49	0.50
1.60-1.69	0.32	
1.70-1.79	0.43	
1.80-1.89	0.51	
1.90-1.99	0.56	
2.00-2.09	0.60	
2.10-2.19	0.51	
2.20-2.29	0.54	0.55
2.30-2.39	0.56	
2.40-2.49	0.47	
2.50-2.69	0.67	0.65
2.70-2.79	0.97	0.95
2.80-2.99	0.96	
3.00-3.29	1.00	1.00
3.30-3.49	0.99	0.99
3.50-3.79	0.90	
3.80-3.99	0.88	0.88
4.00-4.49	0.82	0.82
4.50+	0.66	0.66

TABLE 13. rainbow trout - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference coordinates
0.00-0.09	0.26	0.25
0.10-0.19	0.40	0.40
0.20-0.29	0.55	0.55
0.30-0.39	0.60	0.60
0.40-0.49	0.70	0.70
0.50-0.59	0.66	
0.60-0.69	0.72	0.75
0.70-0.79	0.88	0.88
0.80-0.89	1.00	1.00
0.90-0.99	0.73	0.73
1.00-1.09	0.69	
1.10-1.19	0.68	0.68
1.20-1.29	0.57	
1.30-1.39	0.55	
1.40-1.49	0.66	0.65
1.50-1.59	0.60	
1.60-1.69	0.48	
1.70-1.79	0.43	0.45
1.80-1.89	0.48	
1.90-1.99	0.45	
2.00-2.19	0.18	
2.20-2.29	0.19	
2.30-2.39	0.30	
2.40-2.49	0.45	
2.50-2.59	0.46	
2.60-2.69	0.42	0.40
2.70-2.89	0.29	
2.90-2.99	0.31	0.30
3.00-3.59	0.30	
3.60-3.79	0.10	0.10
3.80-4.49	0.04	0.04
4.50-4.99	0.03	0.03
5.00+	0.03	0.00 -----

TABLE 14. Depth and velocity utilization and preference of steelhead spawning in the Cedar River (2 studies, 25 redds).

depth interval (feet)	depth composite preference (2 studies, 25 redds)	recommended depth preference
0.00-0.59	0.00	0.00
0.60-0.69	0.00	0.00
0.70-0.99	0.48	0.50
1.00-1.49	1.00	1.00
1.50-1.59	1.00	1.00
1.60-2.19	0.73	0.75
2.20-2.39	0.58	0.60
2.40+	0.06	0.50

TABLE 14. steelhead spawning - continued

velocity interval (feet/second)	velocity composite preference (2 studies, 25 redds)	recommended velocity preference
0.00-1.09	0.00	0.00
1.10-2.09	0.44	0.45
2.10-2.89	0.97	0.97
2.90-3.19	1.00	1.00
3.20-3.29	1.00	1.00
3.30-3.59	0.62	0.62
3.60-3.99	0.62	0.40
4.00-4.49	0.62	0.20
4.50-4.99	0.62	0.10
5.00+	0.62	0.00

TABLE 15. Depth and velocity utilization and preference of resident rainbow trout spawning in tributaries to Packwood Lake (2 studies, 27 redds).

depth interval (feet)	depth composite preference (2 studies, 27 redds)	recommended fallback depth preference
0.00-0.29	0.21	0.00
0.00-0.39	0.21	0.20
0.40-0.49	0.58	0.50
0.50-0.69	0.71	0.70
0.70-0.79	0.79	0.80
0.80-1.09	1.00	1.00
1.10-1.19	1.00	1.00
1.20-1.39	0.44	0.45
1.40-2.49	0.00	0.40
2.50+	NA	0.40

TABLE 15. continued

velocity interval (feet/second)	velocity composite preference (2 studies, 27 redds)	recommended velocity preference
0.00-0.29	0.06	0.06
0.30-0.89	0.10	0.10
0.90-0.99	0.57	0.57
1.00-1.49	0.58	
1.50-1.79	0.91	0.91
1.80-2.39	1.00	1.00
2.40-2.49	1.00	1.00
2.50-2.89	0.44	0.44
2.90-3.69	0.00	0.00
3.70+		0.00

TABLE 16. Depth and velocity utilization and preference by adult resident cutthroat trout.

depth interval (feet)	depth composite preference (5 studies, 251 fish)	recommended fallback depth preference
0.00-0.59	0.00	0.00
0.60-0.69	0.00	0.00
0.70-0.79	0.03	0.03
0.80-0.99	0.05	
1.00-1.09	0.12	0.12
1.10-1.19	0.25	
1.20-1.39	0.27	0.25
1.40-1.49	0.23	
1.50-1.59	0.38	
1.60-1.69	0.40	0.40
1.70-1.89	0.52	0.45
1.90-1.99	0.89	0.90
2.00-2.19	1.00	1.00
2.20-2.29	1.00	1.00
2.30-2.59	0.85	0.85
2.60-2.69	0.80	0.80
2.70-2.99	0.59	
3.00-3.39	0.60	
3.40-3.70	0.58	
3.80-4.99	0.59	
5.00+	0.59	0.60

TABLE 16. resident cutthroat trout - continued

velocity interval (feet/second)	velocity composite preference (6 studies, 261 fish)	recommended velocity preference
0.00-0.09	0.13	0.13
0.10-0.19	0.20	0.20
0.20-0.29	0.51	0.50
0.30-0.49	0.83	
0.50-0.59	0.76	
0.60-0.69	0.95	0.95
0.70-0.79	1.00	1.00
0.80-0.89	0.75	
0.90-0.99	0.69	
1.00-1.09	0.82	
1.10-1.19	0.81	0.80
1.20-1.29	0.43	
1.30-1.49	0.31	
1.50-1.59	0.45	0.45
1.60-1.89	0.53	
1.90-2.29	0.47	
2.30-2.39	0.33	0.33
2.40-2.99	0.14	
3.00-3.49	0.15	0.15
3.50-3.59	0.09	0.09
3.60-3.89	0.06	0.06
3.90+	0.00	0.00

TABLE 17. Depth and velocity utilization and preference of juvenile coho salmon (4 studies, 451 fish).

depth interval (feet)	depth composite preference	recommended fallback depth preference
0.00-0.09	0.25	0.00
0.10-0.39	0.25	0.25
0.40-0.49	0.26	
0.50-0.59	0.64	
0.60-0.79	0.67	
0.80-0.99	0.73	
1.00-1.09	0.27	
1.10-1.19	0.40	
1.20-1.39	0.39	
1.40-1.49	0.51	
1.50-1.59	0.90	0.90
1.60-1.69	0.97	
1.70-1.99	0.82	
2.00-2.19	0.78	
2.20-2.39	0.83	
2.40-2.49	0.89	
2.50-3.29	1.00	1.00
3.30-3.79	0.85	
3.80-3.99	0.94	0.90
4.00+	0.27	0.27

TABLE 17. juvenile coho - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference
0.00-0.09	0.78	0.78
0.10-0.19	1.00	1.00
0.20-0.29	0.96	
0.30-0.39	0.96	0.96
0.40-0.49	0.31	0.31
0.50-0.69	0.20	0.20
0.70-1.09	0.18	
1.10-1.29	0.16	0.16
1.30-1.39	0.11	0.11
1.40-1.79	0.09	0.09
1.80-1.99	0.01	0.01
2.00+	0.00	0.00

TABLE 18. Depth and velocity utilization and preference of chinook salmon juveniles (4 studies, 173 fish).

depth interval (feet)	depth composite preference	recommended fallback depth preference
0.00-0.39	0.00	0.00
0.40-0.49	0.00	0.00
0.50-0.69	0.05	0.05
0.70-0.79	0.14	
0.80-0.99	0.14	
1.00-1.09	0.33	0.33
1.10-1.19	0.37	
1.20-1.49	0.48	0.50
1.50-1.59	0.80	0.80
1.60-2.19	0.94	
2.20+	1.00	1.00

TABLE 18. chinook juveniles - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference
0.00-0.09	0.09	0.09
0.10-0.19	0.17	
0.20-0.29	0.20	0.20
0.30-0.39	0.26	0.26
0.40-0.49	0.93	0.93
0.50-0.59	0.98	
0.60-0.79	1.00	1.00
0.80-0.89	0.78	
0.90-0.99	0.80	
1.00-1.09	0.94	
1.10-1.19	0.90	0.90
1.20-1.29	0.76	
1.30-1.39	0.74	0.75
1.40-1.59	0.38	
1.60-1.79	0.40	
1.80-1.99	0.38	
2.00-2.09	0.51	0.50
2.10-2.19	0.50	
2.20-2.39	0.08	0.08
2.40-2.69	0.07	
2.70-3.59	0.03	0.03
3.60+	0.00	0.00

TABLE 19. Depth and velocity preferences for juvenile and adult bull charr (39 fish, 4 studies).

depth interval (feet)	depth composite preference	recommended fallback depth preference
0.00-0.49	0.00	0.00
0.50-0.69	0.01	0.01
0.70-0.79	0.17	0.17
0.80-0.99	0.27	0.27
1.00+	1.00	1.00

TABLE 19. bull charr - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference
0.00-0.29	0.22	0.22
0.30-0.39	0.26	0.26
0.40-0.59	0.74	0.74
0.60-0.89	0.83	0.83
0.90-1.29	0.48	
1.30-3.29	1.00	1.00
3.30-3.49	0.76	0.76
3.50-4.99	0.46	0.46
5.00+	0.46	0.00

TABLE 20. Depth and velocity preference for spawning bull charr (20 redds) in an east slope Cascade Mts. stream.

sample size 5 on redds 15 not on redds

depth interval (feet)	depth composite preference	recommended fallback depth preference
0.00-0.39	0.00	
0.40-0.89	1.00	
0.90+	0.93	

TABLE 20. spawning bull charr - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference
0.00-0.59	1.00	1.00
0.60-0.99	0.89	
1.00-1.09	0.78	
1.10-1.39	0.75	0.75
1.40-2.49	0.59	
2.50-3.49	0.59	0.50
3.50-4.49	0.59	
4.50+		0.00

TABLE 21. Brook trout (brook charr) depth and velocity preferences in two southern Cascades Mountains streams (4 studies, 39 fish).

depth interval (feet)	composite preference	fallback depth preference	depth	recommended
0.00-0.39	0.00	0.00		
0.40-0.49	0.00	0.00		
0.50-0.69	0.03	0.03		
0.70-0.79	0.06			
0.80-0.89	0.07	0.07		
0.90-1.29	0.44	0.45		
1.30-1.49	0.63			
1.50-2.09	1.00	1.00		
2.10+	0.86	0.86		

TABLE 21. brook trout - continued

velocity interval (feet/second)	velocity composite preference	recommended velocity preference
0.00-0.29	0.66	0.66
0.30-0.79	0.75	0.75
0.80-0.99	0.74	
1.00-1.39	1.00	1.00
1.40-1.49	0.83	
1.50-2.09	0.74	
2.10-2.19	0.78	0.75
2.20-2.29	0.51	0.50
2.30-3.39	0.31	0.30
3.40-3.79	0.07	0.05
3.80+		0.00

TABLE 22. Depth, velocity, and substrate preferences of spawning chum salmon in Kennedy Creek, Duckabush and Dosewallips rivers (8 studies, 138 redds). Depth and velocity preferences for Hood Canal summer chum (4 studies, 83 redds) were tabulated separately from those for normal (November-January) chum (4 studies, 55 redds).

Depth (feet)	Hood Canal summer chum		Fall-winter chum			
	Calculated Preference	Recommended Preference	Calculated Preference	Recommended Preference		
0.00	0.04		0.00	0.56		0.00
0.30	0.04		0.00	0.56		0.00
0.39	0.04		0.10	0.56		0.20
0.40	0.17		0.10	0.56		0.20
0.49	0.17		0.20	0.56		0.40
0.50	0.19		0.20	0.56		0.40
0.59	0.19		0.20	0.56		0.55
0.60	0.78		0.25	0.56		0.55
0.69	0.78		0.95	0.56		0.60
0.70	1.00		1.00	0.56		0.60
0.79	1.00		1.00	0.56		0.65
0.80	0.62		0.80	0.71		0.65
0.90	0.62		0.80	0.71		0.70
0.99	0.62		0.80	0.71		0.79
1.00	0.80		0.80	0.85		0.80
1.09	0.80		0.80	0.85		0.85
1.10	0.94		0.80	0.85		0.85
1.19	0.94		0.80	0.85		0.90
1.20	0.80		0.80	1.00		1.00
1.49	0.80		0.80	1.00		1.00
1.50	0.67		0.80	0.84		0.95
1.69	0.67		0.75	0.84		0.75
1.70	0.67		0.75	0.63		0.70
1.79	0.67		0.70	0.63		0.60
1.80	0.67		0.70	0.53		0.55
2.09	0.67		0.60	0.53		0.50
2.10	0.57		0.60	0.53		0.50
2.49	0.57		0.60	0.53		0.45
2.50	0.57		0.60	0.31		0.40
3.19	0.57		0.60	0.31		0.20
3.20	0.57		0.60	0.09		0.15
3.89	0.57		0.55	0.09		0.10
3.90	0.51		0.55	0.09		0.10
5.00+	0.51	0.50		0.09	0.05	

TABLE 22, continued.

Velocity (ft/sec)	Hood Canal summer chum		Fall-winter chum			
	Calculated	Recommended Preference	Calculated Preference	Recommended Preference		
0.00		0.11	0.10		0.36	0.30
0.09		0.11	0.10		0.36	0.40
0.10		0.16	0.15		0.68	0.45
0.29		0.16	0.15		0.68	0.50
0.30		0.41	0.40		0.68	0.50
0.69		0.41	0.40		0.68	0.65
0.70		0.45	0.40		0.68	0.65
0.79		0.45	0.45		0.68	0.70
0.80		0.45	0.45		0.74	0.70
0.89		0.45	0.45		0.74	0.70
0.90		0.38	0.45		0.74	0.70
1.09		0.38	0.50		0.74	0.70
1.10		0.58	0.50		0.74	0.70
1.39		0.58	0.70		0.74	0.75
1.40		1.00	1.00		0.66	0.75
1.49		1.00	1.00		0.66	0.79
1.50		1.00	1.00		0.79	0.80
1.59		1.00	1.00		0.79	0.80
1.60		1.00	1.00		0.79	0.80
1.69		1.00	1.00		0.79	0.80
1.70		1.00	1.00		0.67	0.80
1.79		1.00	0.90		0.67	0.90
1.80		0.74	0.80		0.67	0.90
1.89		0.74	0.80		0.67	0.90
1.90		0.75	0.80		0.96	0.90
2.09		0.75	0.80		0.96	0.90
2.10		0.80	0.80		0.96	0.90
2.29		0.80	0.80		0.96	0.90
2.30		0.80	0.80		0.90	0.90
2.49		0.80	0.80		0.90	0.94
2.50		0.80	0.80		0.90	0.95
2.59		0.80	0.80		0.90	0.99
2.60		0.80	0.80		1.00	1.00
2.69		0.80	0.80		1.00	1.00
2.70		0.80	0.80		1.00	1.00
2.79		0.80	0.80		1.00	1.00
2.80		0.80	0.80		0.46	0.95
3.29		0.80	0.50		0.46	0.50
3.30		0.49	0.50		0.46	0.45
3.39		0.49	0.50		0.46	0.35

TABLE 22, continued.

3.40	0.49		0.40		0.21	0.30
3.69	0.49		0.30		0.21	0.20
3.70	0.28		0.30		0.21	0.20
3.89	0.28		0.20		0.21	0.20
3.90	0.28		0.20		0.21	0.20
3.99	0.28		0.15		0.21	0.10
4.00	0.28		0.15		0.05	0.10
4.90	0.28		0.05		0.05	0.01
5.00+	0.28		0.00	0.05		0.00

Dominant Substrate		Chum salmon spawning substrate	
		Calculated Preference	Recommended Preference
0	organic	0.11-0.18	0.00
1	silt	0.08-0.18	0.00
2	sand	0.08-0.49	0.00
3	small gravel	0.49-0.76	0.50
4	medium gravel	0.76-1.00	1.00
5	large gravel	0.72-1.00	1.00
6	small cobble	0.62-0.90	1.00
7	large cobble	0.24-0.62	0.25
8	boulder	0.00-0.35	0.00
9	bedrock	no data	0.00

TABLE 23. Depth and velocity preferences for spawning pink salmon in Squire Creek, North Fork Stillaguamish, Dosewallips, and Duckabush rivers (3 studies, 46 redds).

Depth (feet)	Calculated Preference	Recommended Preference
0.00	0.77	0.00
0.49	0.77	0.80
0.50	1.00	0.80
0.60	1.00	1.00
0.69	1.00	1.00
0.70	0.89	1.00
0.99	0.89	0.80
1.00	0.68	0.75
1.19	0.68	0.65
1.20	0.43	0.60
1.29	0.43	0.30
1.30	0.09	0.30
2.09	0.09	0.05
2.10	0.00	0.05
5.00+	0.00	0.01

Velocity (ft/sec)	Calculated Preference	Recommended Preference
0.00	0.45	0.30
0.39	0.45	0.60
0.40	0.80	0.70
0.79	0.80	0.90
0.80	1.00	1.00
0.99	1.00	1.00
1.00	0.85	0.90
1.09	0.85	0.80
1.10	0.75	0.80
1.29	0.75	0.80
1.30	0.80	0.80
1.79	0.80	0.80
1.80	0.83	0.80
1.99	0.83	0.80
2.00	0.24	0.80
4.99	0.24	0.00
5.00+	no data	0.00

Dominant Substrate	Calculated Preference	Recommended Preference
0 organic	0.	0.00
1 silt	0.	0.00
2 sand	0.00-0.60	0.00
3 small gravel	0.60-0.74	0.60
4 medium gravel	0.74-1.00	0.80
5 large gravel	0.77-1.00	1.00
6 small cobble	0.28-0.93	0.50
7 large cobble	0.00-0.28	0.25
8 boulder	0.00	0.00
9 bedrock	no data	0.00

TABLE 24. Depth and velocity preferences for spawning sockeye salmon in the Cedar River (3 study reaches, 3 years, 1,037 redds).

Depth (feet)	Recommended Preference
0.00	0.00
0.20	0.00
0.30	0.45
0.50	1.00
1.50	1.00
1.70	0.50
2.70	0.10
3.70	0.00

Velocity (ft/sec)	Recommended Preference
0.00	0.00
0.10	0.13
0.30	0.38
0.50	0.90
0.70	1.00
2.10	1.00
2.30	0.72
2.70	0.32
2.90	0.08
3.30	0.05
3.70	0.00

Dominant Substrate	Recommended Preference
0 organic	0.00
1 silt	0.00
2 sand	0.00
3 small gravel	0.20
4 medium gravel	0.60
5 large gravel	1.00
6 small cobble	1.00
7 large cobble	0.00
8 boulder	0.00
9 bedrock	0.00

TABLE 25. Depth, velocity, and substrate preference of spawning coho salmon, based on 12 redds in the Dewatto River, December 1999.

Depth (feet)	Calculated Preference	Recommended Preference
0.00	0.00	0.00
0.50	0.00	0.00
1.09	0.00	0.19
1.10	0.20	0.20
1.55	0.20	0.60
1.99	0.20	0.95
2.00	1.00	1.00
2.99	1.00	1.00
3.00	0.00	0.70
4.00	0.00	0.35
5.00+	0.00	0.01

Velocity (ft/sec)	Calculated Preference	Recommended Preference
0.00	0.55	0.05
0.30	0.55	0.20
0.90	0.55	0.60
0.99	0.55	0.80
1.00	1.00	1.00
1.09	1.00	1.00
1.10	1.00	1.00
1.29	1.00	1.00
1.30	1.00	1.00
1.79	1.00	1.00
1.80	1.00	1.00
1.99	1.00	1.00
2.00	1.00	1.00
2.59	1.00	1.00
2.60	0.50	0.95
3.00	0.50	0.50
3.89	0.50	0.05
3.90	0.00	0.00
5.00+	0.00	0.00

Dominant Substrate	Calculated Preference	Recommended Preference
0 organic	NA	0.00
1 silt	0.00	0.00
2 sand	0.00	0.00
3 small gravel	1.00	1.00
4 medium gravel	0.33-1.00	1.00
5 large gravel	0.33	0.33
6 small cobble	0.33	0.20
7 large cobble	0.33	0.10
8 boulder	0.33	0.00
9 bedrock	0.33	0.00